Hydraulic Model Update to Support

Preliminary Engineering

for the

Wet Weather Capacity Improvements

at the

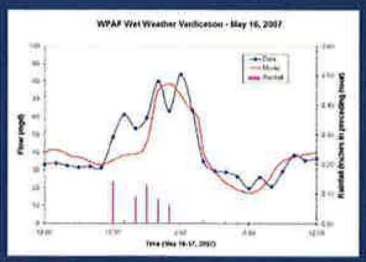
East Street and Boulevard Pump Stations

and the

East Shore Water Pollution Abatement Facility

Prepared for

Greater New Haven Water Pollution Control Authority,
New Haven, Connecticut



CH2MHILL
May 2008
Final Review Draft

GNH0016

Greater New Haven Water Pollution Control Authority

Hydraulic Modeling Update

ATTENDEES:	Brian Gackstatter/NJO	George Elaro, ADS
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	Jim Howey/PHI.	Charlie Biggs, GNHWPCA
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FROM:	William E. McMillin, Jr., P.E.	
DATE:	March 27, 2007	
PROJECT NUMBER:	350590.WW.07.01	

A kickoff meeting was held on March 27, 2007 at the Greater New Haven Water Pollution Control Authority's East Shore Water Pollution Abatement Facility (WPAF) to initiate a Hydraulic Modeling Update project.

The agenda for the meeting was as follows:

1. Introductions and Project History
2. Project Summary and Objectives
3. Project Schedule
4. Task 2 – Model Update – Project List
5. Task 3 – Monitoring Program
6. Task 4 – Revise and Re-verify the Model
7. Task 5 – Run Model Scenarios

Introductions and Project History

Brian Gackstatter made introduction for all in attendance that included representatives of Greater New Haven Water Pollution Control Authority (GNHWPCA), OMI, CH2M HILL and ADS. CH2M HILL will be leading the Hydraulic Modeling Update project. ADS will be performing flow metering in the GNHWPCA collection system.

David Archard provided a brief history of ADS, past work for the GNHWPCA and changes that have been made at ADS since then, and its current capabilities and commitment to the GNHWPCA.

Brian Gackstatter then described the project history. The project is a recommended action of the ongoing project for Preliminary Engineering for the Wet Weather Capacity Improvements at the East Shore WPAF. A hydraulic model was previously developed by CH2M HILL for the GNHWPCA's long-term CSO control planning effort. The model was recovered for the Wet Weather Capacity Improvements project and used to characterize current hydraulic conditions in the collection system for performing preliminary engineering of pump stations and the WPAF. The model then was used to evaluate preliminary engineering alternatives using the two-year design storm in the GNHWPCA's Short and Long Term Control Plan (STCP, LTCP).

Many elements of the STCP and at least one element of the LTCP (Truman Tank) have been implemented since the model was constructed and calibrated.[1] Therefore, CH2M HILL recommended that the hydraulic model be updated by collecting new collection system and WPAF data to verify that the model is representative of existing conditions and performance.

Project team roles are as follows:

- Mike Domenica (Client Service Manager)
- Brian Gackstatter (Project Manager)
- Bill McMillin (Task Leader and Senior QC of Hydraulics)
- Tony Parolari (Hydraulic Modeling)
- Peter Keefe (Senior QC of Flow Monitoring)
- Perrin Niemann (Hydraulic Modeling Consultant/Historian)
- Rita Fordiani, Peter von Zweck (Senior Consultants/Historians)
- David Archard (Flow Metering Contractor Lead)
- George Elaro (Flow Metering Contractor - Field Manager)

Notes from the meeting are as follows:

Project Summary and Objectives

The project has for primary objectives as follows:

1. Update the Model to Reflect 2007 Conditions
2. Conduct a Flow Monitoring Program
3. Revise and Re-verify the Model
4. Run Model Scenarios

Information and data will be collected from the GNHWPCA and OMI to establish existing conditions in the collection system and at the WPAF. The hydraulic model was originally constructed using as-built plans and other information on conveyance, regulators, tide gates, pump stations, siphons, WPAF headwords and other system components. Information will also be gathered to identify the implementation status of STCP and LTCP elements. The information will be compiled to update the model and assure that it is representative of existing conditions.

[1] STCP and LTCP elements are documented in CH2M HILL's Technical Memorandum #14, Long-Term CSO Control Plan, Final Report (April 2001)

A flow monitoring program will be conducted throughout the collection system to observe dry and wet weather flow for a period of at least six weeks. Details of the program will be described below.

Hydraulic elevation and velocity data collected during the flow monitoring program will be used to validate the hydraulic model. If model calculations adequately reproduce observations, the model will be deemed representative of existing conditions. Model parameters may need to be adjusted considering the changes made to the system since the model was originally calibrated.

Model simulations will then be performed using the two-year design storm to characterize existing conditions to prepare for preliminary engineering work.

Project Schedule

The project schedule is shown in Table 1.

TABLE 1
Project Schedule: Hydraulic Model Database Updates and Results Verification

Task	Schedule
Task 1 – Kick-off Meeting and Project Workshop	March 2007
Task 2 – Hydraulic Model Improvements	4/2/07 – 5/18/2007
Task 3 – Short-term Flow Monitoring Program	4/16/2007 – 5/25/2007
Task 4 – Model Performance Evaluation	5/23/2007 – 6/1/2007
Task 5 – Long-term and Extreme Event Simulation	6/1/2007 – 6/15/2007

The project was originally scheduled to start at the beginning of March. Task 3 flow monitoring will most likely begin at the middle to end of April. Flow monitoring may be extended if insufficient rainfall is experienced during the scheduled period. ADS will be able to extend their activities with short notice.

Task 2 – Model Update – Project List

A list of projects planned for implementation was developed from the STCP. CH2M HILL intends to integrate completed projects into the hydraulic model. The project list and status, is as follows:

1. Livingston St, Phase I and II - completed
2. Orange St Phase II - completed
3. Orange, Bishop, and Clinton - completed
4. Lombard St East - ongoing?
5. Wooster Square - completed
6. Humphrey St - completed
7. Kimberly Avenue and Columbus - completed
8. Elm Haven - Phase I and II completed ?
9. Truman Tank - modifications

Exact status of these projects will be verified at a later date. Tony Parolari will meet with the GNHWPCA and OMI to review details on the projects.

Other Data Needs:

- Cross Connections – Most likely not implemented, need to verify.
- Overflow (OF)-002 Closure – Outfall buried by property owner. Discharge most likely obstructed. Dominick Di Gangi gave instructions to seal the overflow.
- Reduce CSO at OF-008 (weir adjustment), OF-010 (seal), Portsea/Liberty (seal), OF-015 (add stop logs) – Most likely not implemented, need to verify.
- Barnes and Quinnipiac Pump Stations – Overflows closed.
- OF-018 - Overflow closed by sewer separation.

Monitoring Program

The flow monitoring program will be of a short duration including site investigations, meter installation, data collection, and mater removal. Flow monitoring will be executed by installing water depth and velocity monitoring devices in the collection system. Flow monitoring is also being conducted concurrently by CDM around the Union Street Pump Station, which will be available to CH2M HILL. The preliminary list of monitoring locations is shown in Table 2.

TABLE 1
Preliminary Flow Metering Locations

Location	Meters Deployed	Data Type
Boulevard Pump Station / OF 024	2	Interceptor, overflow
Boulevard Interceptor / OF 003	2	Interceptor, overflow
Boulevard Interceptor / OF 004	2	Interceptor, overflow
Boulevard Interceptor / OF 005	2	Interceptor, overflow
East St Pump Station / OF 021	2	Interceptor, overflow
Union St Pump Station	1	Pump Station Effluent
OF 010	2	Interceptor, overflow
OF 011	2	Interceptor, overflow
OF 014	2	Interceptor, overflow
Humphrey Pump Station	1	Pump Station Effluent
OF 012	2	overflow
James St Siphon / OF 015	2	Interceptor, overflow
Barnes / Quinnipiac Interceptor	1	Interceptor
Woodward / Lighthouse / Morris Cove Interceptor	1	Interceptor
Total Number of Meters	24	

Dominick Di Gangi questioned the selection of monitoring locations and expressed his concern that all suburban areas are not being monitored, and overflows are not being monitored throughout the system, especially in Fair Haven. CH2M HILL will review and revise the list to assure that all data quality objectives will be met.

Additional comments on the locations:

- "BQI" will have to be upstream of the current location due to property conditions.
- Flow monitoring data from recording devices are available from the pump stations in several formats including circular charts, on-site meters, and telemetry to the WPAF.

Provisions for traffic control were not in the project proposal. Traffic control will have to be coordinated through the GNHWPCA with the New Haven Police Department.

The data objectives are to develop hydraulic elevation, velocity, and calculated flows throughout the collection system for validating the hydraulic model. The goal is to update the model to be representative of existing conditions and validate its appropriateness for preliminary engineering analyses.

Data and information compiled from the GNHWPCA and OMI for STCP and LTCP implementation, other collection system projects and conditions, as well as data collected during the flow monitoring program will be submitted to the GNHWPCA.

Task 4 – Revise and Re-Verify the Model

This task will be performed once sufficient progress is made in Task 2 and while Task 3 is being executed. The model configuration will be updated to represent existing conditions characterized in Task 2. Dry and wet weather calibration periods will be identified from the rainfall record of the Task 3 monitoring period. The model will be validated compared to hydraulic elevation observations and flow calculations/observations for these periods.

Task 5 – Run Model Scenarios

At a minimum, a model simulation will be performed of the existing condition using the two-year design storm in the LTCP. Additional scenarios may be performed to evaluate other conditions identified by the project team that are valuable to preliminary engineering and LTCP implementation.

Actions to be Taken

- CH2M HILL to provide a list of STCP Projects for GNHWPCA confirmation.
- CH2M HILL to provide list of data needs to the GNHWPCA including as-builts, flow data, etc. required for model update.
- CH2M HILL to meet with the GNHWPCA and OMI to review details on the project implementation.
- CH2M HILL to review and revise the list of flow monitoring locations to assure that all data quality objectives will be met including monitoring of suburban areas, overflows and Fair Haven.
- CH2M HILL to coordinate traffic control for the flow monitoring program through the GNHWPCA with the New Haven Police Department.

Greater New Haven Water Pollution Control Authority

Wet Weather Capacity Improvements – Hydraulic Model Update

Hydraulic Model Improvements

PREPARED FOR:	Greater New Haven Water Pollution Control Authority
PREPARED BY:	CH2M HILL
DATE:	April 22, 2008
PROJECT NUMBER:	350590

Introduction

The Greater New Haven Water Pollution Control Authority ("the Authority") maintains a mathematical hydraulic model of its collection system. The model was originally constructed and calibrated during long-term combined sewer overflow (CSO) control planning. The Authority has since used the model to evaluate and finalize engineering alternatives while implementing its short- and long-term control plans. With plan implementation proceeding, the model was out-of-date with respect to changes that were made to the collection system but not simulated in the model. Furthermore, the model was intended to be used as a planning-level tool, and is since being used for more precise engineering design. Therefore, the Authority is conducting a Hydraulic Model Update task to update the model, verify that it accurately represents existing conditions, and to have a more current tool for evaluating engineering alternatives.

The first two actions to be taken in the Hydraulic Model Update task was gathering information and updating the model in a Hydraulic Model Improvements subtask. Information on short- and long-term control plan implementation was gathered as well as any other data or information relative to collection system design and operation. This effort yielded information on sewer separation projects, pump station changes, and other collection system modifications that were relevant to model simulations. The physical representation of the collection system was then updated in the model. This technical memorandum describes the information and data collected as well as the improvements made to the hydraulic model.

Background and Purpose

During recent modeling activities to support Preliminary Engineering for Wet Weather Capacity Improvements, it was found that planning-level hydraulic modeling scenarios

previously developed to support the Authority's Long-Term Control Plan (LTCP) did not include project changes implemented during design and construction phases. Further, the level of detail included in the model, although adequate for planning, is not sufficient for detailed design of system improvements, including prediction of average and peak wet weather flows conveyed to the East Shore Water Pollution Abatement Facility (WPAF).

Because major capital projects (such as the Wet Weather Capacity Improvements) and their associated costs will be based on design information developed using the system model, it is imperative that the model be as up-to-date and accurate as possible for use as a planning and design tool. The Preliminary Engineering recommendations developed by CH2M HILL are based on the existing planning-level hydraulic model. The finalization of these recommendations required the model updates and performance evaluation activities described herein to confirm design parameters and the benefits of these recommendations, prior to the start of detailed design.

Description of Collection System Hydraulic Model

The Authority's collection system hydraulic model was originally developed in 1998 to support the CSO LTCP and calibrated as part of the LTCP development. This planning-level model is documented in LTCP Technical Memorandum #3. Sewer plan maps and as-built drawings were used to construct the model. The software used is MOUSE, a DHI product. The planning-level model was calibrated using several data sources collected in the late 1990s, including:

- Twelve City boundary meters recording flow, depth, and velocity during 1996 and 1997;
- Flow data from the Boulevard, East Street, and East Shore Water Pollution Abatement Facility (WPAF) pumping stations from July 1996 to June 1997;
- Rainfall data collected at the East Shore WPAF from 1994 to 1997 and long-term records from the Tweed Airport, Bradley Airport, and Lake Saltonstall U.S. Geological Survey stations;
- A flow metering program conducted in 1997, described in LTCP Technical Memorandum #5; and,
- A block-testing program and sediment inspection in the Boulevard Interceptor conducted in 1999, which led to further calibration and model updates delivered in November 1999.

The current model has the following scenarios:

- **2007 Existing Conditions** – represents the collection system as it exists.
- **Long-Term Control Plan (LTCP) Scenario I** - represents the 2007 Existing Conditions model with the addition of all the LTCP I recommendations as defined in the Collection System Hydraulic Modeling Report (TM 1A- Collection System Hydraulic Modeling, April 2008); and

- **LTCP Scenario II** - represents the LTCP I model with the addition of all the LTCP II recommendations as defined in the Collection System Hydraulic Modeling Report (TM 1A- Collection System Hydraulic Modeling, April 2008).

Purpose and Goals

The Hydraulic Modeling Update task delivers a planning-level hydraulic model that accurately represents current collection system conditions that is appropriate for supporting long-term planning and design of major conveyance projects. The hydraulic model may require additional refinement in the future to support detailed catchment studies or facility design projects. The model updates and performance evaluation were necessary to complete Preliminary Engineering of Wet Weather Capacity Improvements.

The purpose of this hydraulic model improvements subtask was to update the Authority's hydraulic model to reflect 2007 existing conditions in the collection system. The following actions were completed as a part of the Hydraulic Modeling Update task:

- Conducted a short-term, flow-monitoring program;
- Evaluated model performance to verify that the model reflects current conditions; and,
- Prepared model scenarios for LTCP planning and design evaluations.

The goal of the Hydraulic Model Improvements subtask was to prepare an updated hydraulic model suitable for continued planning purposes, with the following scenarios:

- **2007 Existing Conditions;**
- **Long-Term Control Plan (LTCP) Scenario I**; and
- **LTCP Scenario II.**

This technical memorandum describes technical work efforts performed in the Hydraulic Model Improvements subtask to compile information and physically update the hydraulic model to 2007 existing conditions.

Methodology for Model Updates

The methodology to update the hydraulic model consisted of several key information and data compilation efforts that focused on modifying the planning-level hydraulic model to represent existing collection system conditions. A data request was submitted to the Authority on April 4, 2007 to request and track the compilation of information on STCP and LTCP implementation, other collection system projects, or operational information related to collection system performance. This was conducted to define hydraulic model data needs.

The information and data collection effort was focused on collecting the information necessary to update the model as follows:

- Several sewer separation projects performed as part of the Authority's STCP have been completed; others are near completion. The locations and characteristics of the separation projects were collected and verified by reviewing as-built plans. Similar information was collected on field corrections to cross-connections and modifications made to combined sewer regulators and overflows.
- Field verification of pump station equipment and/or operations and other system components was conducted. Pump curves based on differential head were collected or developed from manufacturer and field test data. Pump control logic was also compiled. Force main fittings, bends, expansions and contractions, and other sources of localized energy losses were derived from system as-built drawings. True force main profiles and ground surface elevations were developed to facilitate accurate prediction of system operating pressures.
- The Truman Tank was constructed along the Boulevard Interceptor as part of implementing the Authority's LTCP. However, the tank was not constructed in the location originally recommended in the LTCP due to site constraints. As-built plans and contract documents used in design support as well as current operational procedures were compiled.
- Operations at the headworks of the WPAF were verified with Authority personnel.

Data and information compiled for this task was prepared in spreadsheet format to be compatible with model import formats. The hydraulic model database and scenarios were then revised. A 2007 Existing Condition model was constructed with the updated information compiled for drainage areas, conveyance, regulating structures, outfalls, pump stations, force mains, storage tanks, WPAF headworks, and other system components that affect hydraulics. The overall conceptual elements and CSO control goals of the LTCP are unchanged.

Existing Model Updates

The information and data collection effort yielded valuable data on sewer separation projects, pump stations, cross connections, CSO regulators and outfalls, and the construction and operation of the Truman Tank. Projects or operation changes conducted to implement the short- and long-term control plans will affect runoff, conveyance, and control of dry and wet weather flow, CSOs, and WPAF performance. Therefore, CSO outfalls affected by the projects are also noted for reference. The following describes the information gathered and modifications made to the model necessary to accurately simulate the collection system.

Sewer Separation Projects

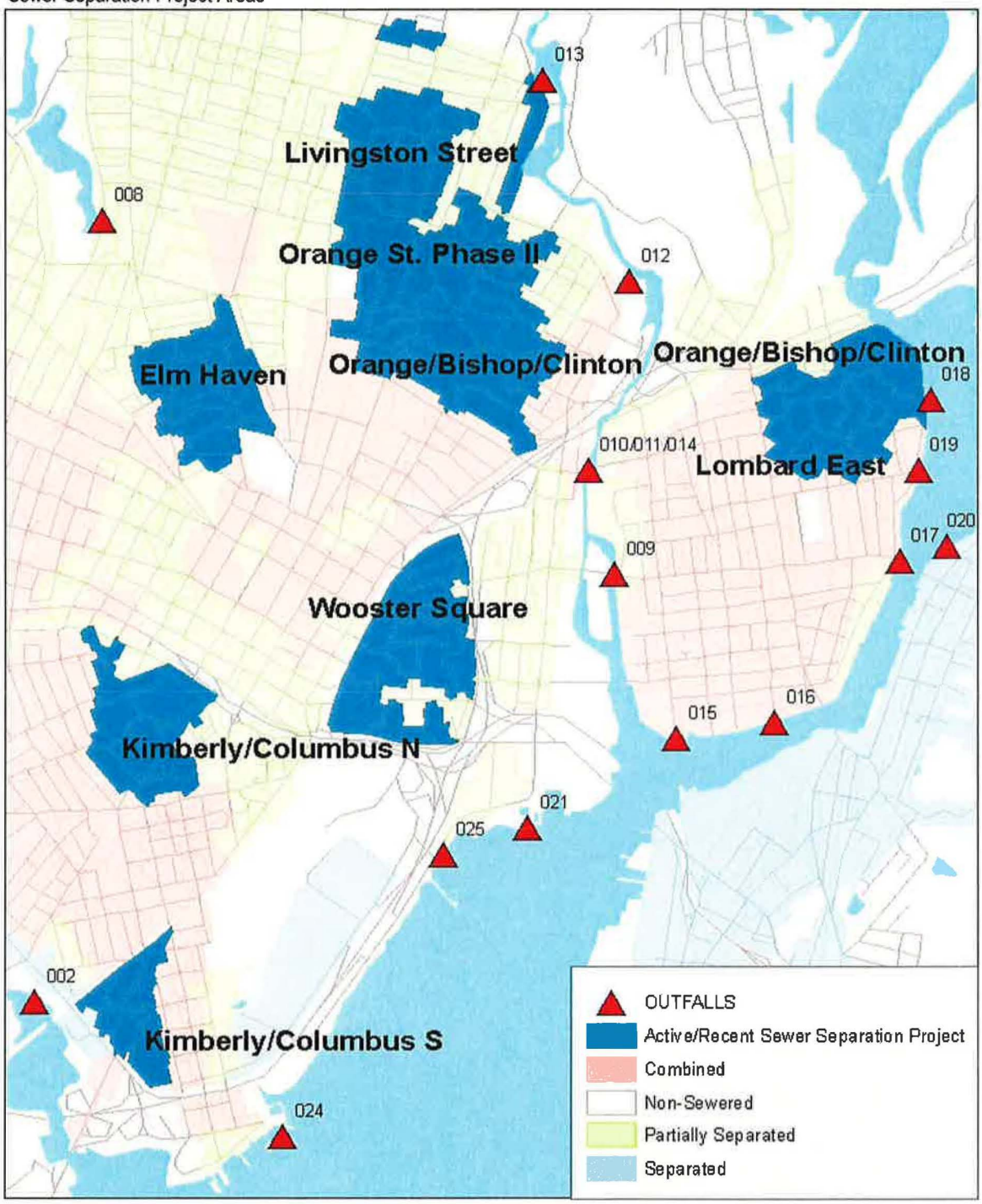
A number of sewer separation projects were active (ongoing) at the time of long-term control planning, and were integrated as elements of the STCP. Many of these projects are

completed, some are substantially completed (as-builts pending), and the remaining projects have been divided into phases and are partially complete. The following eight sewer separation projects were considered active during original model development and/or were listed in the Authority's STCP (CH2M HILL, 2001):

- Livingston Street Phases I and II (not in STCP),
- Orange Street Phase II,
- Orange/Bishop/Clinton/(Middletown),
- Lombard Street East Phase I,
- Wooster Square,
- Kimberly/Columbus North
- Kimberly/Columbus South,
- Humphrey Street (later revised to two projects: North and South),
- Elm Haven Phases I and II, and
- Lombard Street East Phase II.

Exhibit 1 illustrates the project areas and combined sewer outfalls affected by the projects.

EXHIBIT 1
Sewer Separation Project Areas



As-built plans and contract documents, GIS data, and the model catchment database were used to develop the information necessary to update the hydraulic model and accurately simulate completed or ongoing sewer separation projects. The following steps were followed to identify the model catchments affected by separation and determine model changes necessary to reflect as-built conditions:

1. Identify streets and blocks separated in each project using as-builts, etc.
2. Identify combined sewers that were separated along these streets in the GIS.
3. Overlay modeled runoff catchments with separated streets to identify associated catchments.
4. Determine the Areal Reduction Factor (ARF) necessary to accurately represent rainfall-runoff characteristics in the model.

The ARF was used during the Authority's original LTCP modeling effort to address differences between the runoff response from combined, separated, and partially separated sewer systems. It represents the "effective" area for each type of sewer system and reflects the variation in response. For example, combined sewers do not capture 100% of the rain because of surface ponding and direct runoff to receiving waters, while separated areas may exhibit a significant response to wet weather due to infiltration and inflow (I/I). Adjusting the ARF in the model only changes the effective runoff area, it does not change surface runoff characteristics such as percent imperviousness or hydraulic pipes and connections in the model. A detailed description of the ARF can be found in the Authority's LTCP Technical Memorandum #3 (CH2M HILL, 1998, pp. 88).

The ARFs used in the Authority's hydraulic model are as follows:

- Combined (C) – It is assumed that approximately 25% of rainfall is lost to direct runoff to waterbodies or in poorly drained areas, so that only 75% of the catchment can be considered hydraulically effective.
- Partially Separated (P) – In these areas, construction projects have rerouted runoff from streets in storm sewers, but runoff from roofs is still directed in the sanitary sewers. The ARF for partially separated catchments is 25%. In some separated catchments, the sewer separation project did not address all catch basins in the catchment. An ARF of 50% is assigned to these catchments, which are identified as such in the discussion to follow.
- Separated (S) – For separated areas, the ARF is 10% to allow for a small runoff contribution to sanitary sewers.

The following describes each sewer separation project and how they are represented in the Authority's hydraulic model update.

Livingston Street Phases I and II

Portions of the Livingston Street Phases I and II separation project were ongoing or completed at the time of long-term control planning. This project directly affects combined sewer overflows to the Mill River at CSO outfall 012 and 013. The 2007 Existing Conditions, LTCP Scenario I, and LTCP Scenario 2 hydraulic model were constructed to reflect the major portions already completed. Since as-built drawings or contract documents were not available for the project, it is not clear how to determine which areas were actually separated by project phases. Therefore, the Authority's GIS database was referenced for information regarding the current status of catchments in this area.

The GIS database yielded information indicating that at least one additional catchment (Q08N100) was separated than earlier anticipated for the Livingston Street project when long-term control planning was conducted - an area along Cliff Street at the northern border of the City of New Haven. Exhibit 2 illustrates the areas anticipated and actually separated by the project, and the remaining area along Livingston Street.

The left panel of Exhibit 2 illustrates the actual condition (combined, partially separated, or separated) of each catchment as represented in the LTCP Study. All of these catchments are specified as partially separated with the exception of the combined area along Livingston Street, between East Rock Street and Cold Spring Street.

The right panel of Exhibit 2 illustrates the status of each catchment as represented in the most recent GIS database (Applied Geographics, 2007). In this data, the Cliff Street catchment is shown as partially separated; whereas the Livingston Street catchment is still combined. Therefore, the 2007 Existing Conditions, LTCP I, and LTCP II hydraulic models were updated to represent the Cliff Street catchments as partially separated, with an ARF of 25%, and the Livingston Street catchment as combined.

Exhibit 3 summarizes the status of each catchment in the Livingston Street Phase I and II area, and how it is simulated in the model using modeled effective areas.

EXHIBIT 2
Livingston Street Phases I and II Sewer Separation Project Areas

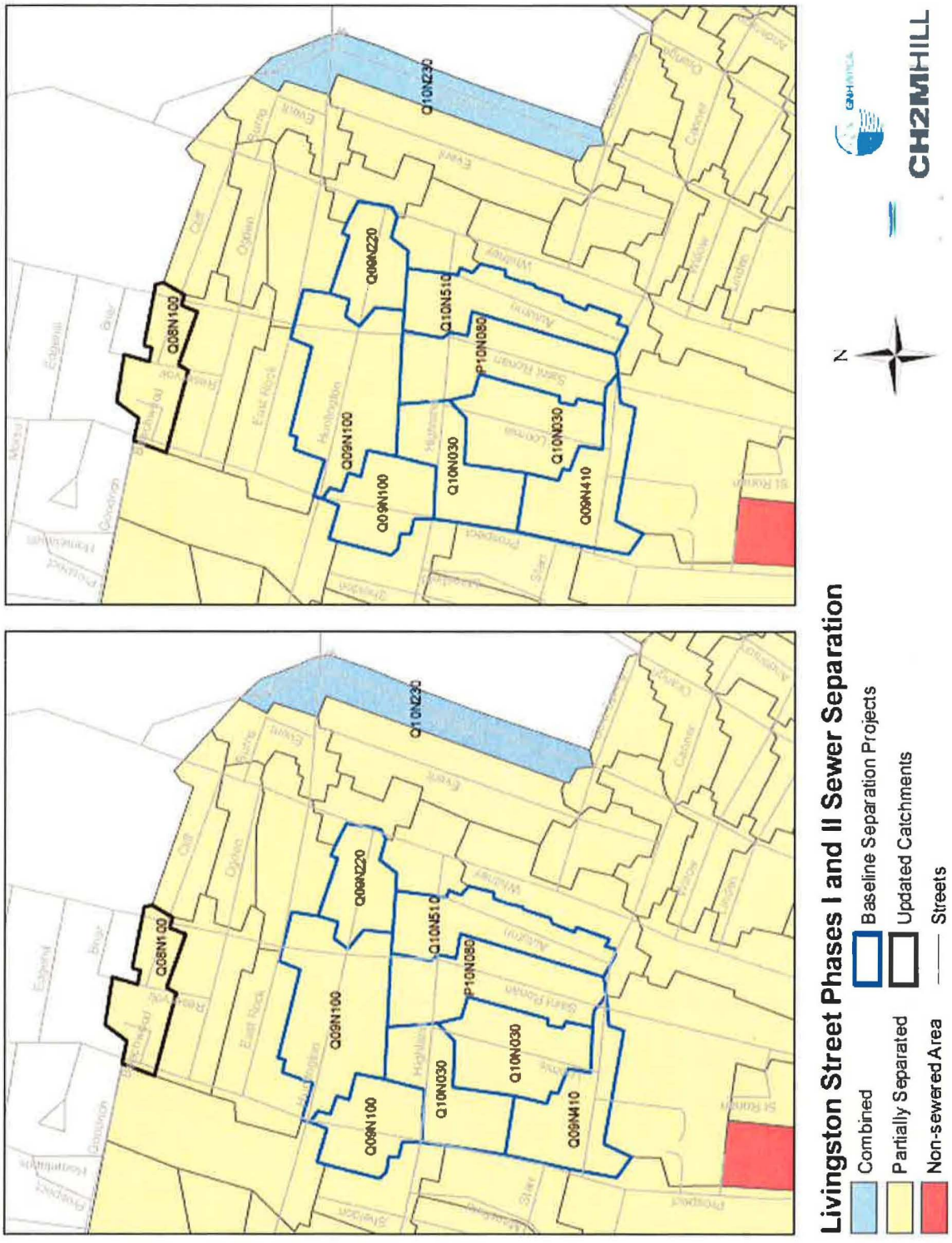


EXHIBIT 3
Livingston Street Phases I and II Sewer Separation Projects Catchment Status and Modeled Areas

Catchment ID	Catchment Status			Modeled Effective Area (acres)			
	1997 Conditions Model	LTCP Study Assumption	2007 Existing Conditions Model	Actual Total	1997 Conditions Model	LTCP Study Assumption	2007 Existing Conditions Model
P10N080	C	P	P	13.9	10.4	3.5	3.5
Q09N100	C	P	P	8.2	6.2	2.1	2.1
Q09N100	C	P	P	17.5	13.1	4.4	4.4
Q09N220	C	P	P	6.9	5.2	1.7	1.7
Q09N410	C	P	P	10.8	8.1	2.7	2.7
Q10N030	C	P	P	11.2	8.4	2.8	2.8
Q10N030	C	P	P	9.6	7.2	2.4	2.4
Q10N230	C	C	C	14.4	10.8	10.8	10.8
Q10N510	C	P	P	11.3	8.5	2.8	2.8
Q08N100	C	P	P	7.8	5.8	1.9	1.9
Total	-	-	-	111.6	83.7	35.1	35.1

Note: Catchment status notation describes ARF assignment of C = Combined (75% runoff reduction), P = Partially Separated (50% runoff reduction), and S=Separated (10% runoff reduction) in the hydraulic model.

Orange Street Phase II

The Orange Street Phase II sewer separation project was completed in September 2003. This project area is approximately centered on Saint Ronan Street, Lawrence Street, Foster Street, and Cold Spring Street. The project directly affects combined sewer overflows to the Mill River at outfalls 010 and 012. Exhibit 4 illustrates the areas anticipated and actually separated for the project.

Exhibit 4 illustrates how the as-built separated area matches well with that originally anticipated - all catchments originally anticipated for separation were partially separated; except Edward Street between Prospect Street and Whitney Avenue. Upon further inspection of sewer separation as-built drawings, it was found that this street was instead partially separated under the Orange/Bishop/Clinton sewer separation project discussed below.

The geographic land area that encompasses the Orange Street project is 174.2 acres; of which 122.5 acres (approximately 70% of the land area) contribute wet weather flow to the system. The LTCP Study modeled effective area following planned sewer separation was to be reduced by approximately 64% to 43.6 acres. There is no change to the modeled effective area in the 2007 Existing Condition model. Exhibit 5 summarizes the status of each catchment in the Orange Street Phase II area, and how it is simulated in the model using modeled effective areas.

EXHIBIT 4
Orange Street Phase II Sewer Separation Project Areas

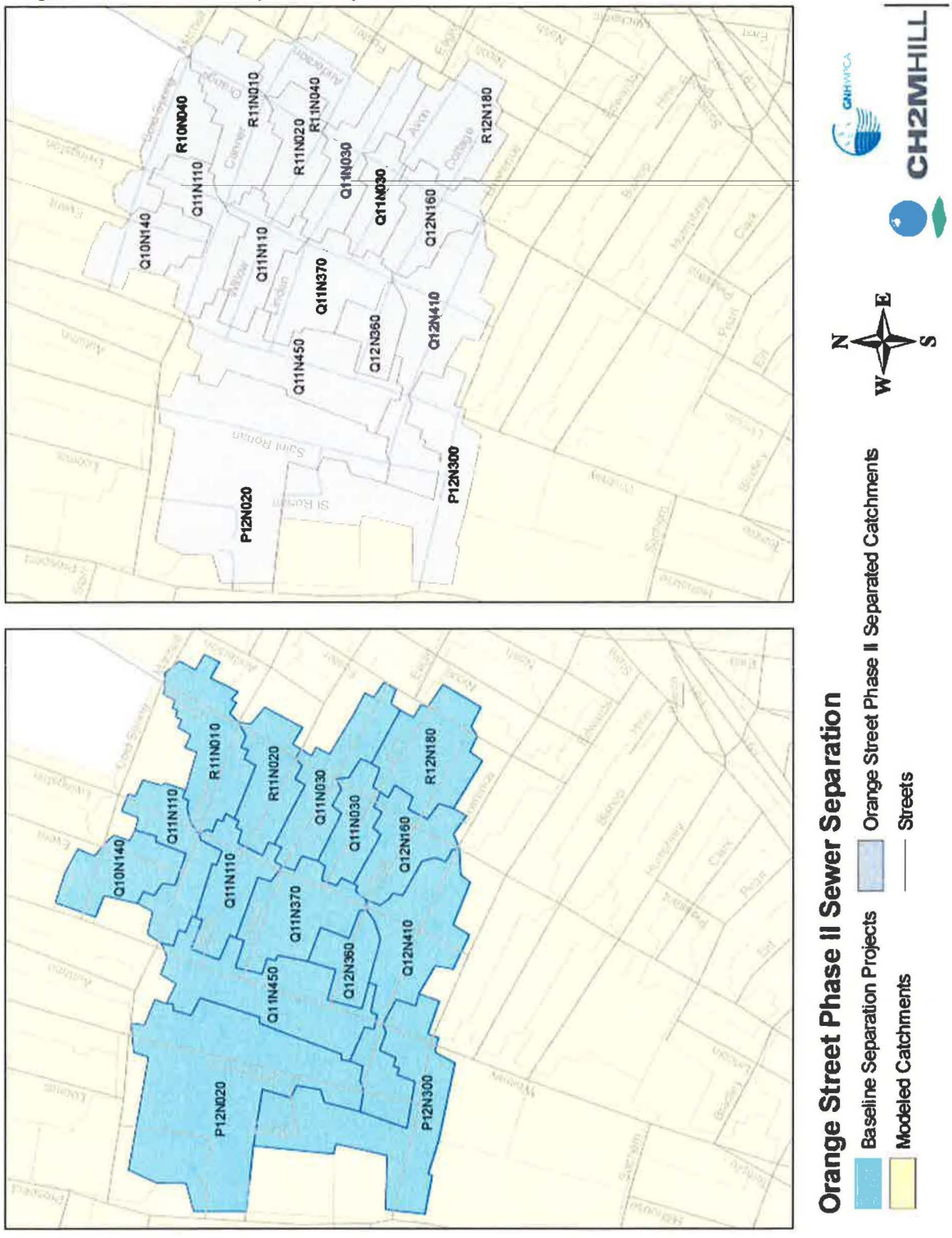


EXHIBIT 5
Orange Street Phase II Sewer Separation Project Catchment Status and Modeled Areas

Catchment ID	Catchment Status			Modeled Effective Area (acres)			
	1997 Conditions Model	LTCP Study Assumption	2007 Existing Conditions Model	Actual Total	1997 Conditions Model	LTCP Study Assumption	2007 Existing Conditions Model
P12N020	C	P	P	29.8	22.4	7.5	7.5
P12N300[1]	C	P	P	17.2	12.9	4.3	4.3
Q10N140	C	P	P	7.0	5.3	1.8	1.8
Q11N030	C	P	P	5.1	3.8	1.3	1.3
Q11N030	C	P	P	8.6	6.5	2.2	2.2
Q11N110	C	P	P	6.5	4.9	1.6	1.6
Q11N110	C	P	P	7.7	5.8	1.9	1.9
Q11N370	C	P	P	9.4	7.1	2.4	2.4
Q11N450	C	P	P	13.8	10.3	3.4	3.4
Q12N160	C	P	P	7.2	5.4	1.8	1.8
Q12N360	C	P	P	4.2	3.2	1.1	1.1
Q12N410	C	P	P	14.9	11.2	3.7	3.7
R10N040	P	P	P	7.4	1.8	1.8	1.8
R11N010	P	P	P	9.8	7.4	2.5	2.5
R11N020	C	P	P	7.0	5.2	1.8	1.8
R11N040	C	P	P	8.9	2.2	2.2	2.2
R12N180	C	P	P	9.8	7.3	2.4	2.4
Total	-	-	-	174.3	122.7	43.7	43.7

[1]This catchment was separated under both the Orange Street Phase II and Orange/Bishop/Clinton projects.

Orange/Bishop/Clinton

The Orange/Bishop/Clinton sewer separation project was completed in August 2004. This project is located in two areas divided by the Mill River, one being west of the river, and the other east of the river in Fair Haven. The project directly affects combined sewer overflows to the Mill River at outfalls 010 and 011, and overflows to the Quinnipiac River at outfall 018 and downstream outfalls. Exhibits 6 and 7 illustrate the areas anticipated and actually separated by the project.

The West area is centered on Bishop Street, Edwards Street, and Lawrence Street between I-91 and Whitney Avenue, west of the Mill River. All catchments originally anticipated for sewer separation were partially separated in this project. Additional areas along Lawrence Street west of Nash Street has been separated but the balance of the catchment (R13N350) remains combined and Edwards Street, between Prospect Street and Whitney Avenue, were

also partially separated by the project. Both of these changes are reflected in the 2007 Existing Condition model. Exhibit 6 illustrates the status of each catchment in the West area.

The Fair Haven area separated in the Orange/Bishop/Clinton project is centered on Front Street and I-91 in northern Fair Haven. Two of the five catchments separated in Fair Haven were not anticipated in the original sewer separation project, as they were previously considered partially separated. See the Lombard Street East section below for further discussion of sewer separation in Fair Haven. Exhibit 7 illustrates the status of each catchment in the Fair Haven area.

The geographic land area of the entire the Orange/Bishop/Clinton project is 170.0 acres; of which 106.0 acres (approximately 62% of the land area) contribute wet weather flow to the system. The LTCP Study effective area after sewer separation is reduced by approximately 58% to 44.4 acres. The modeled effective area is 44.4 acres for the 2007 Existing Conditions model (a 58% reduction). Exhibit 8 summarizes the status of each catchment in the Orange/Bishop/Clinton project, and how it is simulated in the model using modeled effective areas.

EXHIBIT 6
Orange/Bishop/Clinton Sewer Separation Project (West) Areas

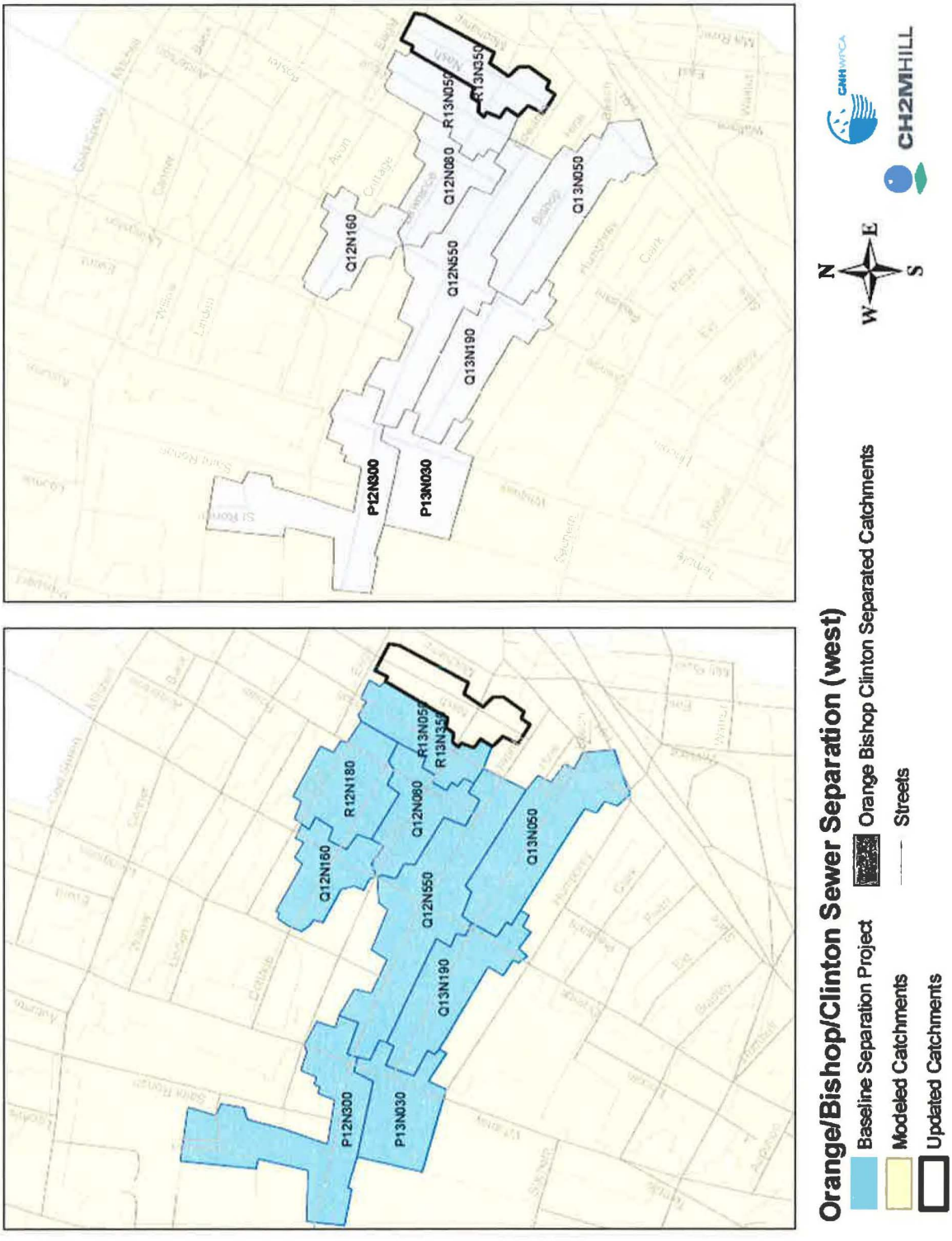


EXHIBIT 7
Orange/Bishop/Clinton Sewer Separation Project (Fair Haven) Areas

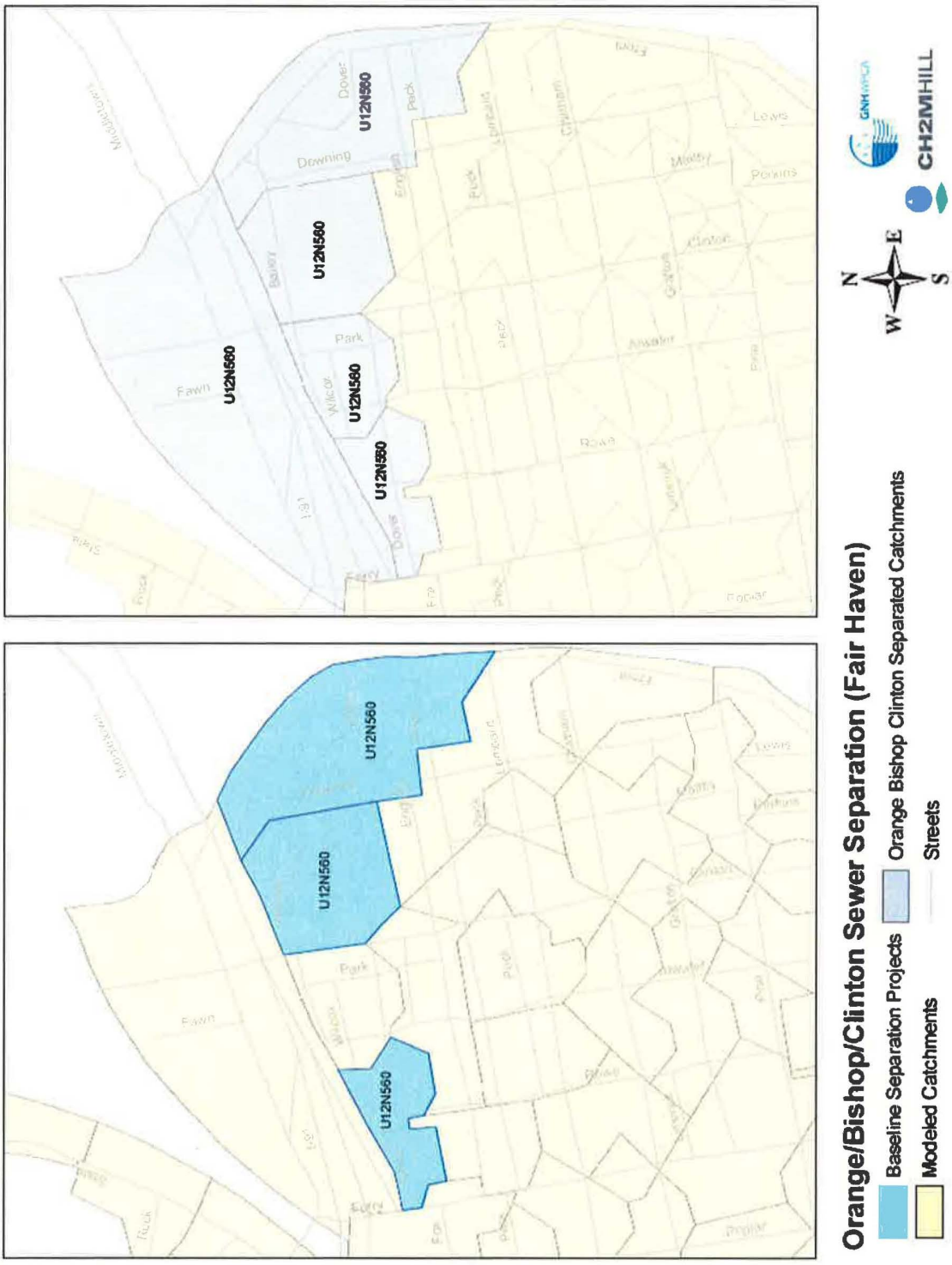


EXHIBIT 8
Orange/Bishop/Clinton Sewer Separation Project Catchment Status and Modeled Areas

Catchment ID	Catchment Status			Modeled Effective Area (acres)			
	1997 Conditions Model	LTCP Study Assumption	2007 Existing Conditions Model	Actual Total	1997 Conditions Model	LTCP Study Assumption	2007 Existing Conditions Model
P12N300	C	P	P	17.2	12.9	4.3	4.3
P13N030	C	P	P	9.0	6.7	2.2	2.2
Q12N080	C	P	P	8.0	6.0	2.0	2.0
Q12N550	C	P	P	19.4	14.5	4.8	4.8
Q13N050	C	P	P	14.3	10.8	3.6	3.6
Q13N190	C	P	P	10.8	8.1	2.7	2.7
R13N050	C	P	P	7.4	5.5	1.8	1.8
R13N350	C	P[1]	P[1]	7.6	5.7	3.8	3.8
U12N560	C	P	P	17.5	13.1	4.4	4.4
U12N560	C	P	P	10.3	7.7	2.6	2.6
U12N560	C	P	P	5.6	4.2	1.4	1.4
U12N560	P	P	P	37.0	9.2	9.2	9.2
U12N560	P	P	P	6.0	1.5	1.5	1.5
Total	-	-	-	170.1	105.9	44.3	44.3

[1] Sewer separation project did not separate all catch basins in this catchment. Therefore, an ARF of 50% was assigned to this catchment.

Lombard Street East Phase I

The Lombard Street East Phase I sewer separation project was completed in November 2001. This project was added as part of the Orange/Bishop/Clinton project in areas along Lombard Street and Front Street on the eastern side of Fair Haven. The project directly affects combined sewer overflows to the Quinnipiac River at outfall 018 and downstream outfalls. Exhibit 9 illustrates how the areas anticipated and actually partially separated by the project match very closely.

The geographic land area that encompasses the Lombard Street East Phase I project is 32.1 acres; of which 24.1 acres (75% of the land area) contribute wet weather flow to the system. The LTCP Study modeled effective area with anticipated sewer separation was reduced by approximately 67% to 8.0 acres. No model changes were necessary for the modeled effective areas in the 2007 Existing Condition model. Exhibit 10 summarizes the status of each catchment in the Lombard Street East Phase I project, and how it is simulated in the model using modeled effective areas.

EXHIBIT 9
Lombard Street East Phase I Sewer Separation Project Areas

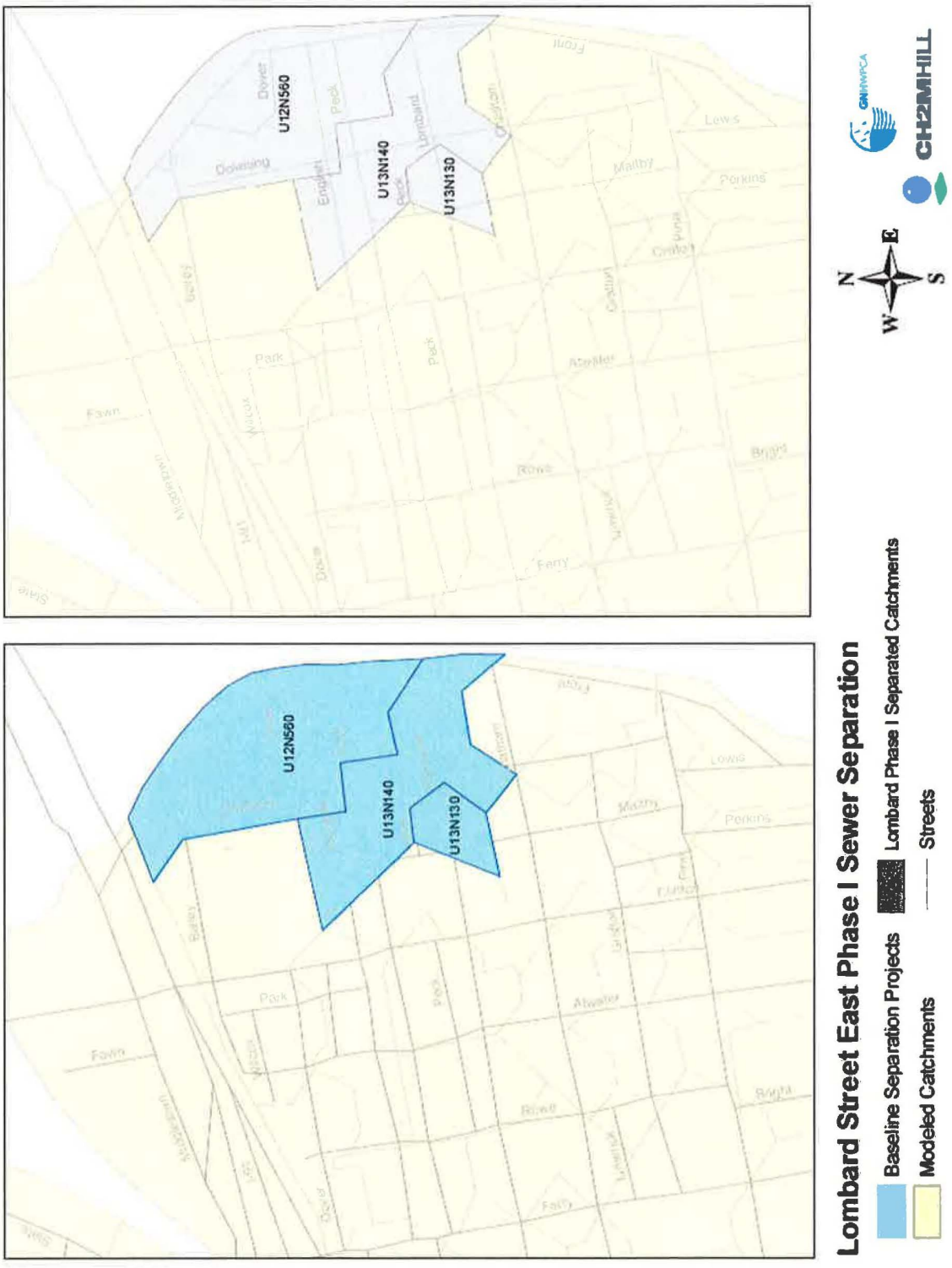


EXHIBIT 10
Lombard Street Phase I Sewer Separation Project Catchment Status and Modeled Areas

Catchment ID	Catchment Status			Modeled Effective Area (acres)			
	1997 Conditions Model	LTCP Study Assumption	2007 Existing Conditions Model	Actual Total	1997 Conditions Model	LTCP Study Assumption	2007 Existing Conditions Model
U13N130	C	P	P	2.5	1.9	0.6	0.6
U13N140	C	P	P	12.1	9.1	3.0	3.0
U12N560	C	P	P	17.5	13.1	4.4	4.4
Total	-	-	-	32.1	24.1	8.0	8.0

Wooster Square

The Wooster Square sewer separation project was completed in August 2001. This project covers an area approximately anchored by Union Street, Water Street, Lyon Street, and I-91. Combined sewer overflows to New Haven Harbor at outfall 021 are directly affected by this project. Exhibit 11 illustrates the areas planned and actually partially separated by the project.

The as-built drawings provided by the Authority indicate that all catchments originally planned for this sewer separation project were separated, except the following:

- Catchment Q15N500 – William Street between Olive Street and Bradley Street, and
- Catchment Q17N280 – Franklin Street between Wooster Street and Green Street.

In addition, the as-built drawings indicate that the sewer main along Wooster Street, between Brown Street and Franklin Street, was separated. The LTCP Study model simulation represented this entire catchment as partially separated; however, the separated area is only approximately 25% of Catchment Q17N450.

The geographic land area that encompasses the Wooster Square project is 126.6 acres; of which 88.5 acres (approximately 70% of the land area) contribute wet weather flow to the system. The LTCP Study modeled effective area after sewer separation is reduced by approximately 51% to 43.0 acres.

Exhibit 12 summarizes the status of each catchment in the Wooster Square area, and how it is simulated in the model using modeled effective areas.

EXHIBIT 11
Wooster Square Sewer Separation Project Areas

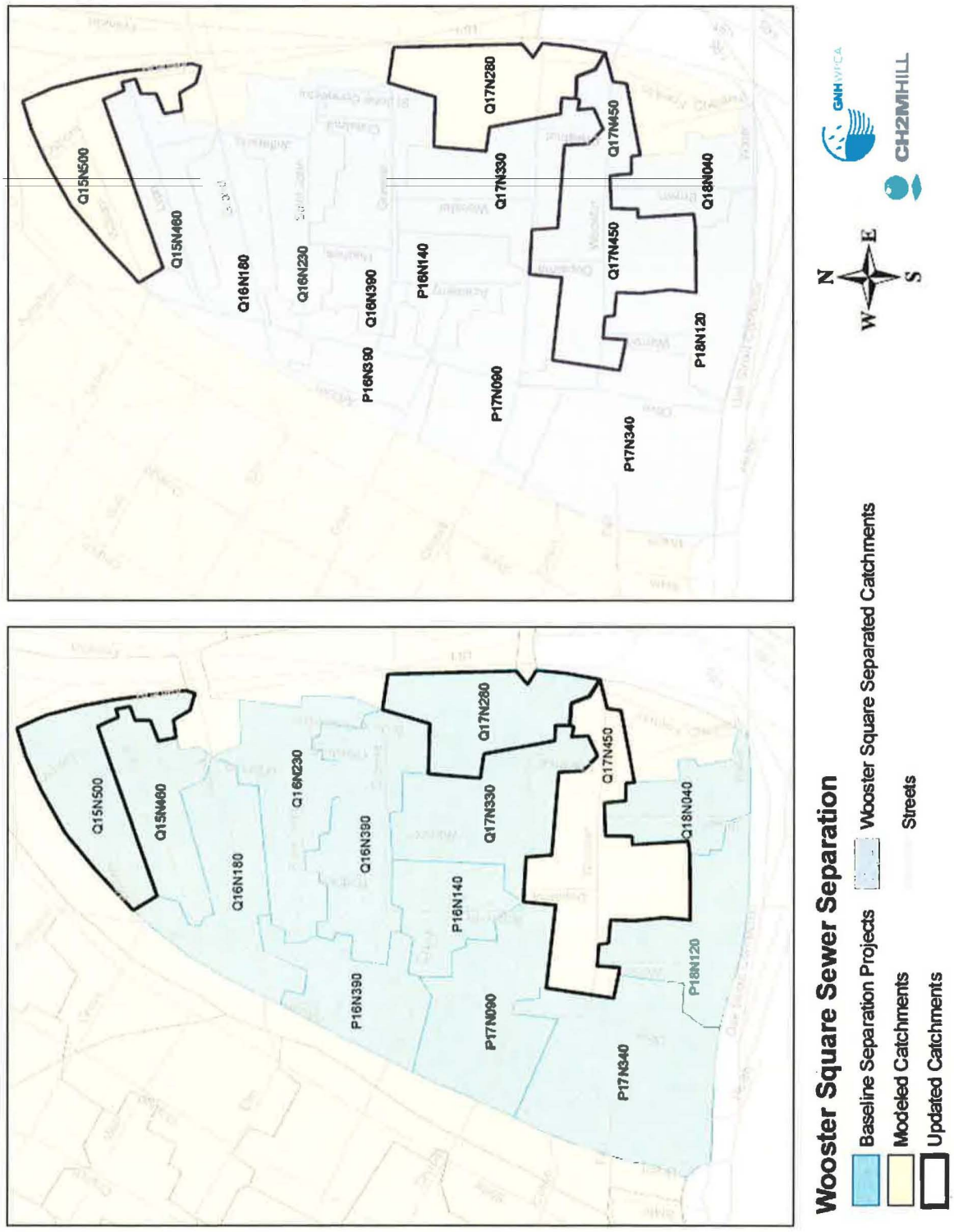


EXHIBIT 12
Wooster Square Sewer Separation Project Catchment Status and Modeled Areas

Catchment ID	Catchment Status			Modeled Effective Area (acres)			
	1997 Conditions Model	LTCP Study Assumption	2007 Existing Conditions Model	Actual Total	1997 Conditions Model	LTCP Study Assumption	2007 Existing Conditions Model
P16N140	C	P	P	5.4	4.1	1.4	1.4
P16N390	C	P	P	7.3	5.4	1.8	1.8
P17N090	C	P	P	10.5	7.8	2.6	2.6
P17N340	C	P	P	16.0	12.0	4.0	4.0
P18N120	C	P	P	8.1	6.0	2.0	2.0
Q15N460	C	P	P	6.7	5.0	1.7	1.7
Q15N500	C	C	C	8.4	6.3	6.3	6.3
Q16N180	C	P	P	9.3	7.0	2.3	2.3
Q16N230	C	P	P	9.4	7.1	2.4	2.4
Q16N390	C	P	P	9.9	7.5	2.5	2.5
Q17N280	C	C	C	7.7	5.8	5.8	5.8
Q17N330	C	P	P	9.7	7.2	2.4	2.4
Q17N450	P	P[1]	P[1]	12.9	3.2	6.5	6.5
Q18N040	C	P	P	5.4	4.1	1.4	1.4
Total	-	-	-	126.7	88.5	43.1	43.1

[1]As-built drawings show that the Wooster Square sewer separation project did not separate all catch basins in this catchment. Therefore, an ARF of 50% was assigned to this catchment.

Kimberly/Columbus North

The Kimberly/Columbus North Sewer Separation Project was completed in November 2002. The project is divided into two areas, North and South. The North area is anchored on its north side at the terminus of Route 34, directly affecting combined sewer overflows to New Haven Harbor at outfall 025. The South area is anchored to its south along Ella T Grasso Boulevard, directly affecting combined sewer overflows to New Haven Harbor at outfall 024.

The Kimberly/Columbus North sewer separation project is anchored on Howard Street, Congress Street, and Washington Street. Exhibit 13 illustrates how the areas anticipated and actually partially separated by the North project match closely. However, several of the catchments are only partially separated with respect to area (as-builts show that not all combined sewers were separated on the streets). Catchment areas were updated in the 2007 Existing Condition model to accurately reflect field conditions.

The geographic land area of the Kimberly/Columbus North project is 82.3 acres; of which 61.7 acres (approximately 75% of the land area) contribute wet weather flow to the system.

The LTCP Study modeled effective area after sewer separation is reduced by approximately 53% to 29.1 acres.

Exhibit 14 summarizes the status of each catchment in the Kimberly/Columbus North area, and how it is simulated in the model using modeled effective areas.

EXHIBIT 13
Kimberly/Columbus North Sewer Separation Project Areas

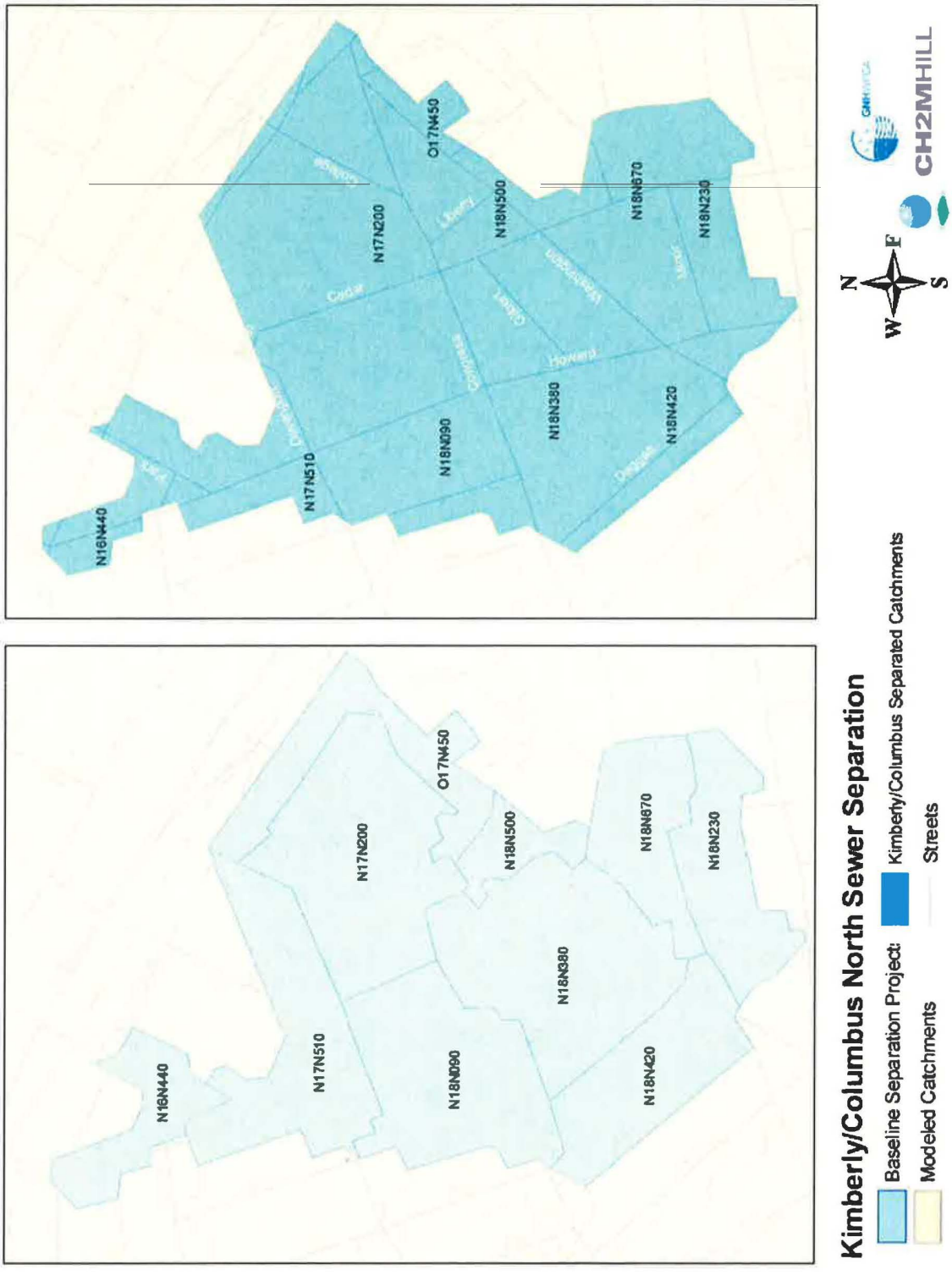


EXHIBIT 14

Kimberly/Columbus North Sewer Separation Project Catchment Status and Modeled Areas

Catchment ID	Catchment Status			Modeled Effective Area (acres)			
	1997 Conditions Model	LTCP Study Assumption	2007 Existing Conditions Model	Actual Total	1997 Conditions Model	LTCP Study Assumption	2007 Existing Conditions Model
N16N440	C	P[1]	P[1]	4.5	3.4	2.3	2.3
N17N200	C	P[1]	P[1]	13.2	9.9	6.6	6.6
N17N510	C	P[1]	P[1]	10.2	7.7	5.1	5.1
N18N090	C	P	P	11.1	8.4	2.8	2.8
N18N230	C	P[1]	P[1]	6.7	5.0	3.4	3.4
N18N380	C	P	P	13.7	10.3	3.4	3.4
N18N420	C	P	P	7.8	5.9	2.0	2.0
N18N500	C	P	P	2.4	1.8	0.6	0.6
N18N670	C	P[1]	P[1]	6.0	4.5	3.0	3.0
O17N450	C	P[1]	P[1]	6.5	4.9	3.3	3.3
Total	-	-	-	82.1	61.8	32.5	32.5

[1] As-built drawings show that the Kimberly/Columbus North sewer separation project did not separate all catch basins in this catchment. Therefore, an ARF of 50% was assigned to this catchment.

Kimberly/Columbus South

The Kimberly/Columbus South Sewer Separation Project was completed in January 2003. This project centers on Kimberly Avenue between I-95 and Cassius Street. Exhibit 15 illustrates the areas anticipated and actually partially separated by the North project. Several catchments originally anticipated for separation were not actually separated by this project. The catchment areas for N21N180 and N21N660 were updated in the 2007 Existing Condition model as combined catchments to reflect field conditions. Also, the catchment areas for N21N350 and N22N240 were updated in the 2007 Existing Condition model as partially separated to reflect field conditions.

The geographic land area that encompasses the Kimberly/Columbus South project is 56.4 acres; of which 42.3 acres (approximately 75% of the land area) contribute wet weather flow to the system. The LTCP Study modeled effective area after sewer separation is reduced by approximately 39% to 25.9 acres.

Exhibit 16 summarizes the status of each catchment in the Kimberly/Columbus South area, and how it is simulated in the model using modeled effective areas.

EXHIBIT 15
Kimberly/Columbus South Sewer Separation Project Areas

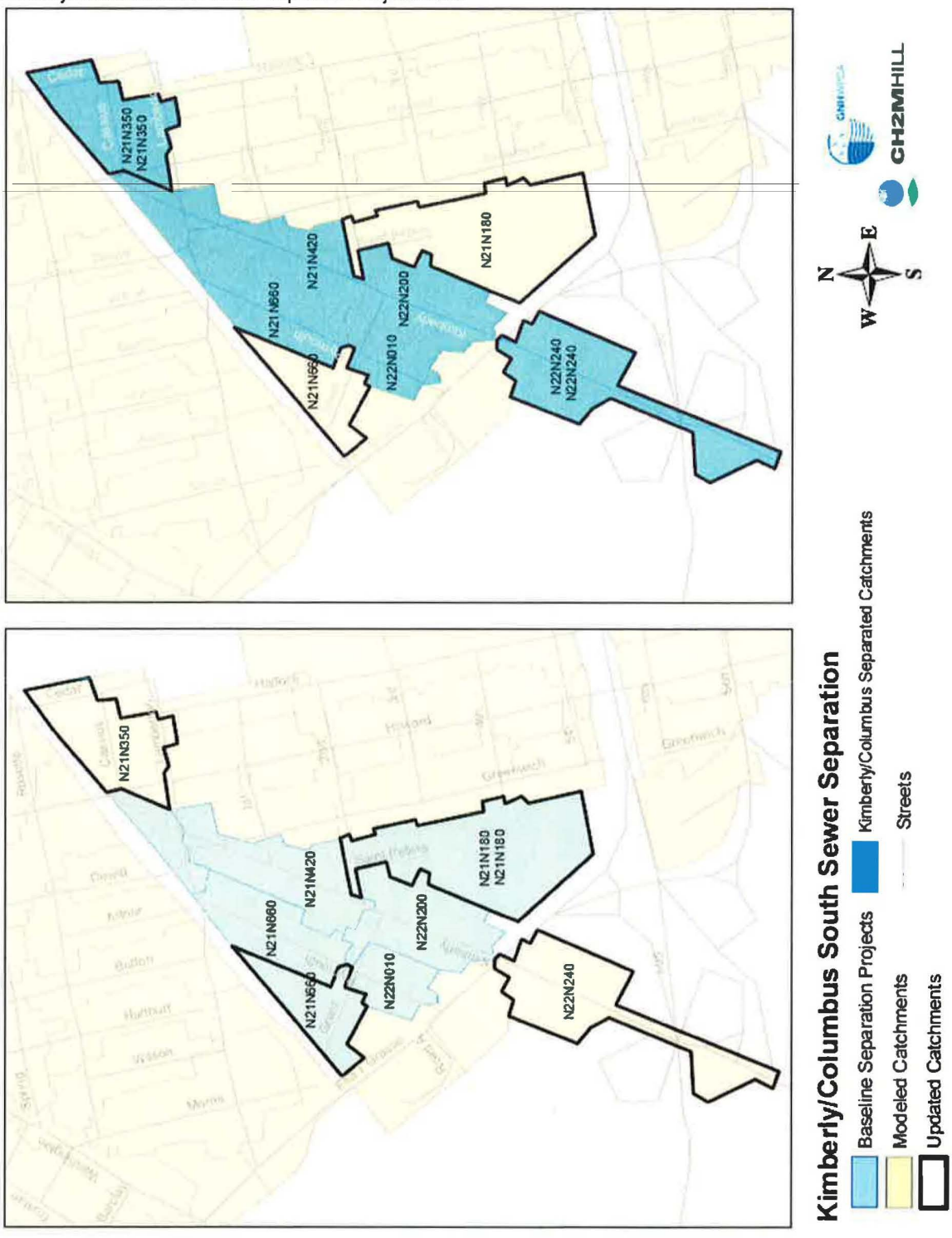


EXHIBIT 16
Kimberly/Columbus South Sewer Separation Project Catchment Status and Modeled Areas

Catchment ID	Catchment Status			Modeled Effective Area (acres)			
	1997 Conditions Model	LTCP Study Assumption	2007 Existing Conditions Model	Actual Total	1997 Conditions Model	LTCP Study Assumption	2007 Existing Conditions Model
N21N180	C	C	C	13.4	10.1	10.1	10.1
N21N350	C	P[1]	P[1]	7.2	5.4	3.6	3.6
N21N420	C	P	P	2.5	1.9	0.6	0.6
N21N420	C	P	P	7.8	5.8	1.9	1.9
N21N660	C	C	C	4.5	3.4	3.4	3.4
N21N660	C	P	P	6.0	4.5	1.5	1.5
N22N010	C	P	P	3.2	2.4	0.8	0.8
N22N200	C	P	P	7.4	5.5	1.8	1.8
N22N240	C	P[1]	P[1]	4.4	3.3	2.2	2.2
Total	-	-	-	56.4	42.3	25.9	25.9

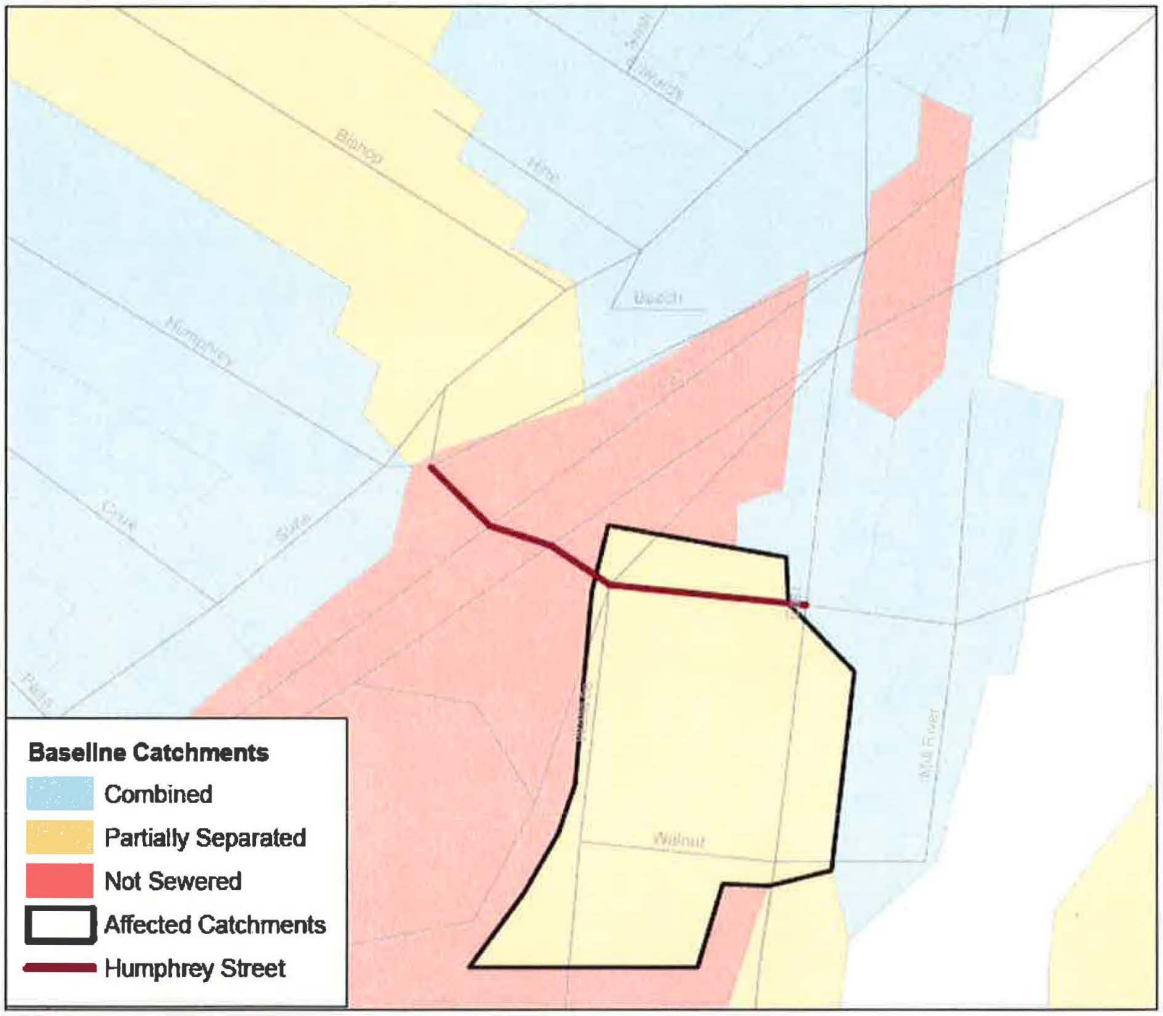
[1] As-built drawings show that the Kimberly/Columbus South sewer separation project did not separate all catch basins in this catchment. Therefore, an ARF of 50% was assigned to this catchment.

Humphrey Street

The Humphrey Street sewer separation project was completed in January 2002. This project is centered on Humphrey Street between State Street and East Street. The project directly affects combined sewer overflows to the Mill River at outfall 010.

As-built drawings were not available for review. Therefore, contract drawings were referenced for information regarding the status of each catchment in this area. The catchments addressed in this project are in a relatively small area and are designated partially separated in the LTCP Study. Therefore, no model changes are necessary. Exhibit 17 illustrates the status of each catchment in the Humphrey Street area, and how it is simulated in the model using modeled effective areas.

EXHIBIT 17
Humphrey Street Sewer Separation Project Area

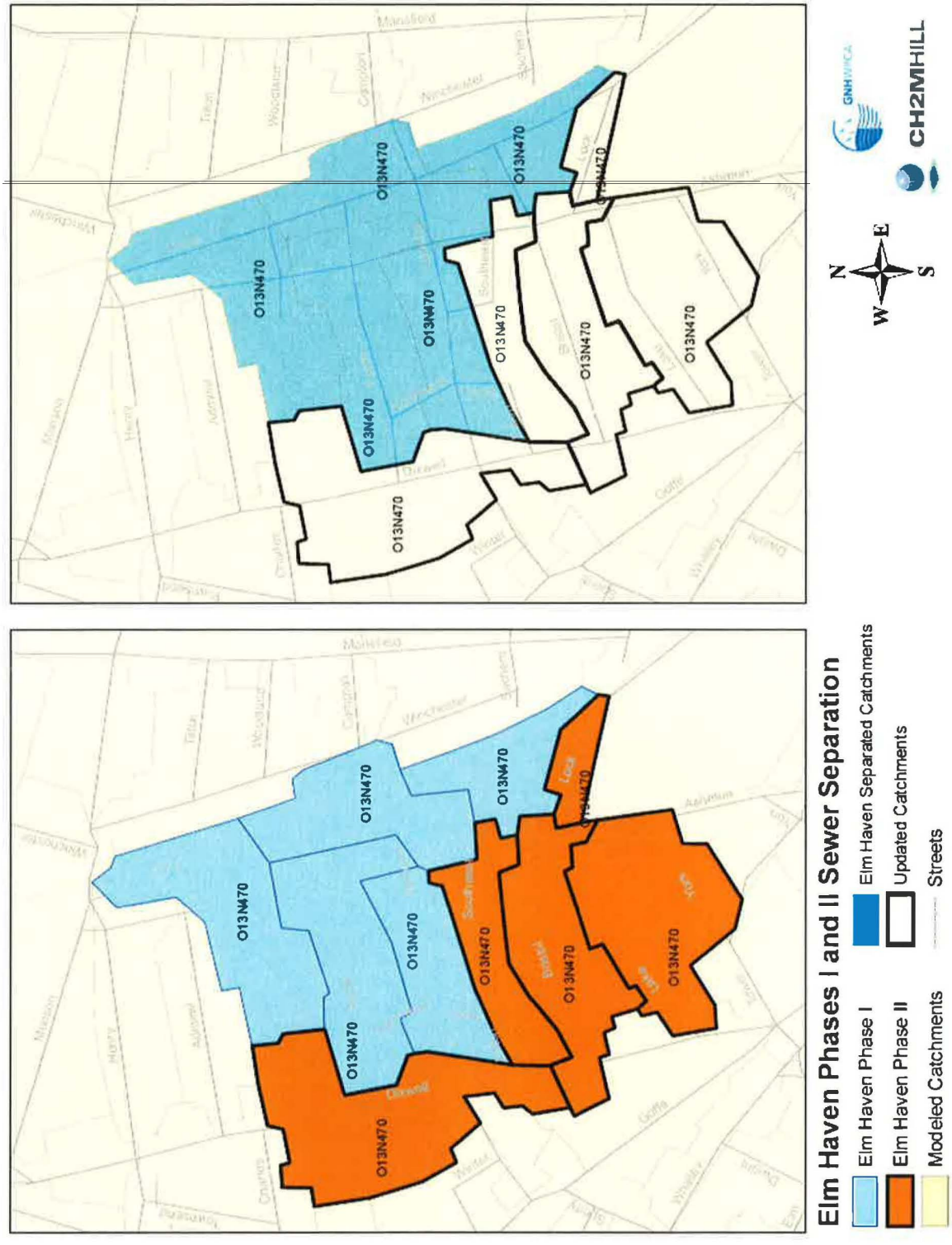


Elm Haven Phases I and II

There are two phases to the Elm Haven sewer separation project. All areas of both phases are illustrated in Exhibit 18. The project directly affects combined sewer overflows to the Mill River at outfall 014.

Phase I was completed in August 2001, separating combined sewer areas along Canal Street and Ashmun Street in Elm Haven. This project is centered on Humphrey Street between State Street and East Street. The catchments partially separated by the Phase I project exactly match those originally anticipated.

EXHIBIT 18
Elm Haven Phases I and II Sewer Separation Project Areas



The Elm Haven Phase II sewer separation project, according to the Authority, partially separated two catchments, partially separated parts of two other catchments, and one catchment remains combined.

The actual geographic land area that encompasses the Elm Haven Phase I and II projects is 87.6 acres. Approximately 81.4 acres of this was partially separated.

Exhibit 19 summarizes the status of each catchment in the Elm Haven Phases I and II areas, and how it is simulated in the model using modeled effective areas.

EXHIBIT 19
Elm Haven Phases I and II Sewer Separation Project Catchment Status and Modeled Areas

	Catchment Status			Modeled Effective Area (acres)			
Catchment ID[1]	1997 Conditions Model	LTCP Study Assumption	2007 Existing Conditions Model	Actual Total	1997 Conditions Model	LTCP Study Assumption	2007 Existing Conditions Model
O13N470	C	P	P	11.3	8.5	2.8	2.8
O13N470	C	P	P	8.5	6.4	2.1	2.1
O13N470	C	P	P	10.5	7.8	2.6	2.6
O13N470	C	P	P	6.9	5.2	1.7	1.7
O13N470	C	P	P	5.6	4.2	1.4	1.4
O13N470*	C	C	C	6.2	4.7	4.7	4.7
O13N470*	C	P[1]	P[1]	14.3	10.8	7.2	7.2
O13N470*	C	P[1]	P[1]	12.1	9.1	6.1	6.1
O13N470*	C	P	P	10.0	7.5	2.5	2.5
O13N470*	C	P	P	2.2	1.7	0.6	0.6
Total	-	-	-	87.6	65.9	31.7	31.7

[1]All catchments in the Elm Haven Phases I and II area drain to the same node in the hydraulic model. Therefore, they are assigned an identical Catchment ID. Geographic area (actual) values were used to distinguish between the different areas.

* Elm Haven Phase II

Lombard Street East Phase II

The Lombard Street East Phase II project separates areas in Fair Haven. Combined sewer overflows to the Quinnipiac River at outfall 018 are directly affected by this project, as well as downstream outfalls. Contract drawings for the Lombard Street East Phase II sewer separation project were delivered to the Authority in August 2006 (Westcott & Mapes, 2006). Authority records indicate that this project was 90% complete as of June 2007. As illustrated in Exhibit 20, this project separates several combined sewer catchments in Fair Haven, included in original plans for separation but not separated in the Lombard Street East Phase I or Orange/Bishop/Clinton projects. One catchment, along English Street and Peck Street, between Rowe Street and Ferry Street, was not separated in any of the Fair Haven projects.

The actual geographic land area that encompasses the Lombard Street East Phase II project is 64.6 acres, with 48.4 acres contributing to wet weather flow in the system (approximately 75%).

In addition to catch basin separation, this project involves the construction of a new 42-inch storm drain in Lombard Street. This storm drain will direct stormwater runoff directly to a new outfall near Lombard Street and Front Street. A new diversion structure and 30-inch dry weather flow pipe was constructed under the Lombard Street East Phase I project. Also, the existing 36-inch overflow pipe (CSO 018) was plugged at Front Street and connected to the Front Street Interceptor (Westcott & Mapes, 2006; City of New Haven, 1999). These changes were made to the 2007 Existing Condition model.

Exhibit 21 summarizes the status of each catchment in the Lombard Street East Phase II area, and how it is simulated in the model using modeled effective areas.

EXHIBIT 20

Lombard Street East Phase II Sewer Separation Project Areas

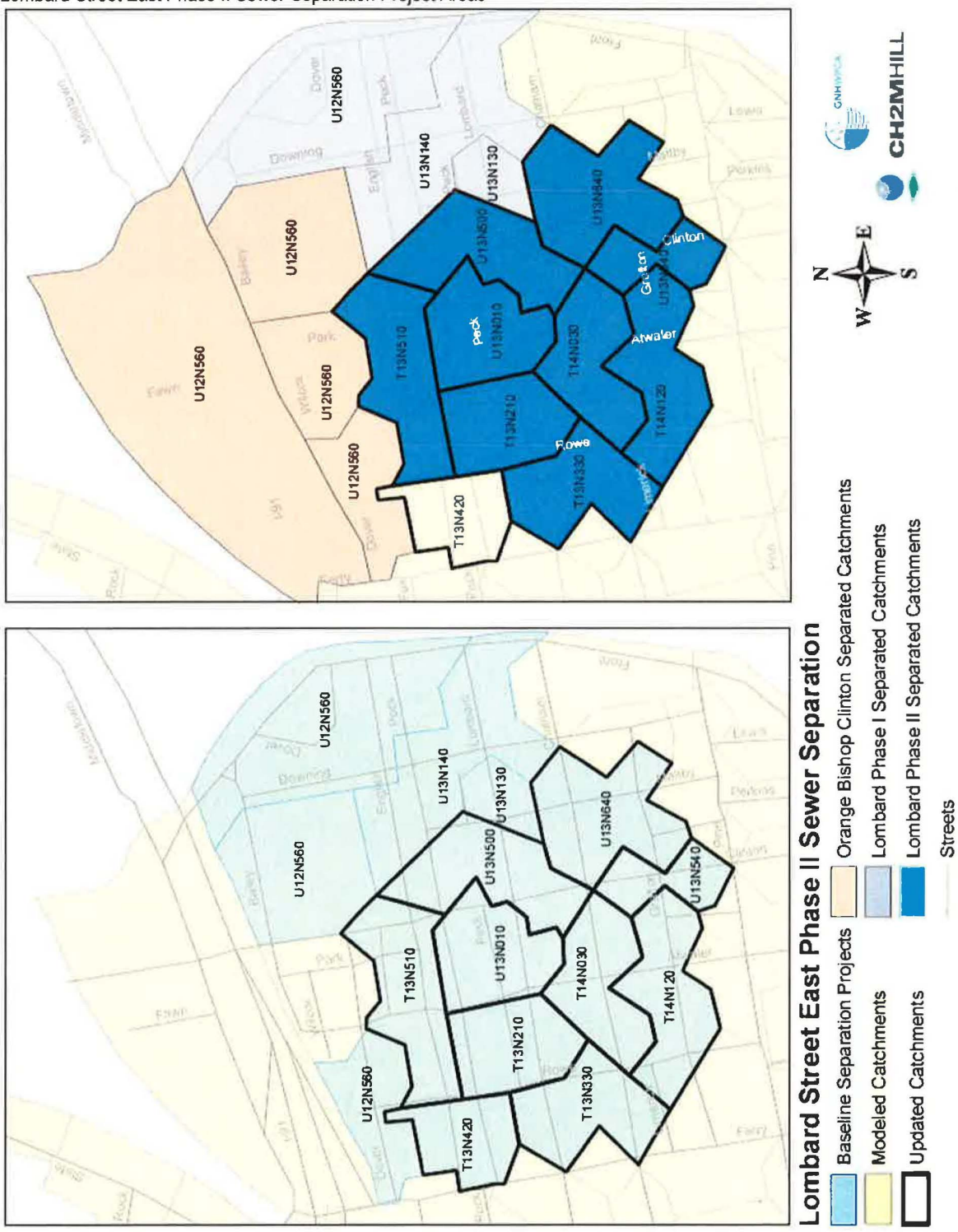


EXHIBIT 21
Lombard Street East Phase II Sewer Separation Project Catchment Status and Modeled Areas

Catchment ID[1]	Catchment Status			Modeled Effective Area (acres)			
	1997 Conditions Model	LTCP Study Assumption	2007 Existing Conditions Model	Actual Total	1997 Conditions Model	LTCP Study Assumption	2007 Existing Conditions Model
T13N210	C	P	P	6.0	4.5	1.5	1.5
T13N330	C	P	P	6.5	4.9	1.6	1.6
T13N420	C	C	C	4.8	3.6	3.6	3.6
T13N510	C	P	P	7.7	5.8	1.9	1.9
T14N030	C	P	P	6.4	4.8	1.6	1.6
T14N120	C	P	P	7.3	5.5	1.8	1.8
U13N010	C	P	P	6.5	4.9	1.6	1.6
U13N500	C	P	P	7.5	5.7	1.9	1.9
U13N540	C	P	P	3.4	2.5	0.8	0.8
U13N640	C	P	P	8.4	6.3	2.1	2.1
Total	-	-	-	64.5	48.5	18.4	18.4

Fair Haven Sewer Separation

The planned Fair Haven sewer separation project calls for full separation of all the catchments. Exhibit 22 represents the 2007 Existing Conditions and Exhibit 23 represents the planned sewer separation. Exhibit 22 presents both the partially separated and combined catchments located in the Fair Haven area. The partially separated catchments were recently separated during the Lombard Street Phase I, Lombard Street Phase II, and Orange/Bishop/Clinton sewer separation projects as shown in Exhibits 7, 9, and 20. These catchments will be fully separated along with the remaining combined catchments during the planned Fair Haven sewer separation project. The LTCP Scenarios I and II hydraulic models are based on planned Fair Haven sewer separation. Exhibit 24 represents the actual and model effective areas for all the catchments located in the Fair Haven area. The geographic land area that encompasses the Fair Haven is approximately 651 acres; of which 379 acres (approximately 58% of the land area) contribute wet weather flow to the system for 2007 Existing Conditions. The LTCP Study modeled effective area after planned sewer separation is reduced by 90% to 65 acres.

EXHIBIT 22
Sewer Separation in Fair Haven for 2007 Existing Conditions

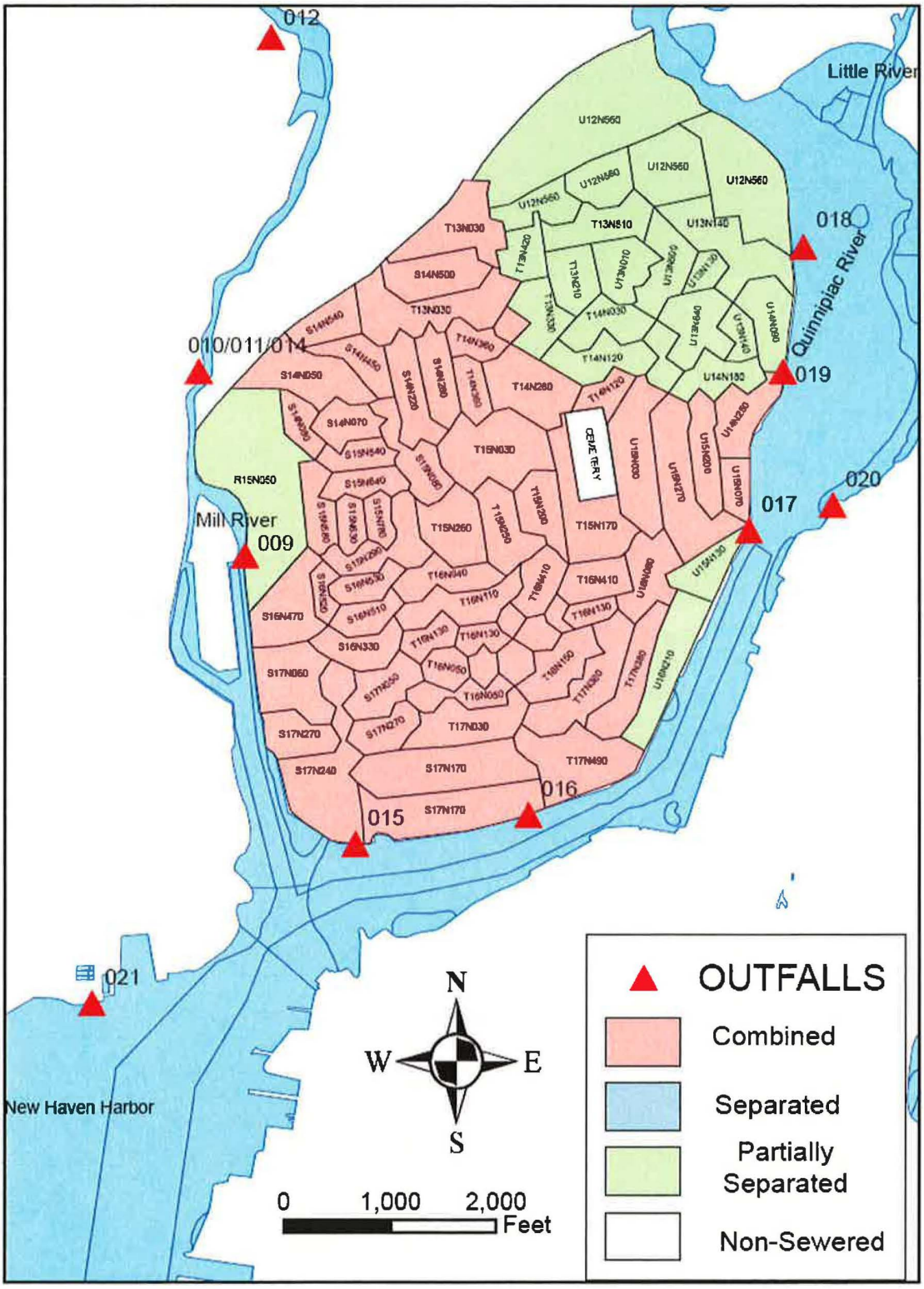


EXHIBIT 23
Planned Sewer Separation in Fair Haven as Modeled in LTCP Conditions

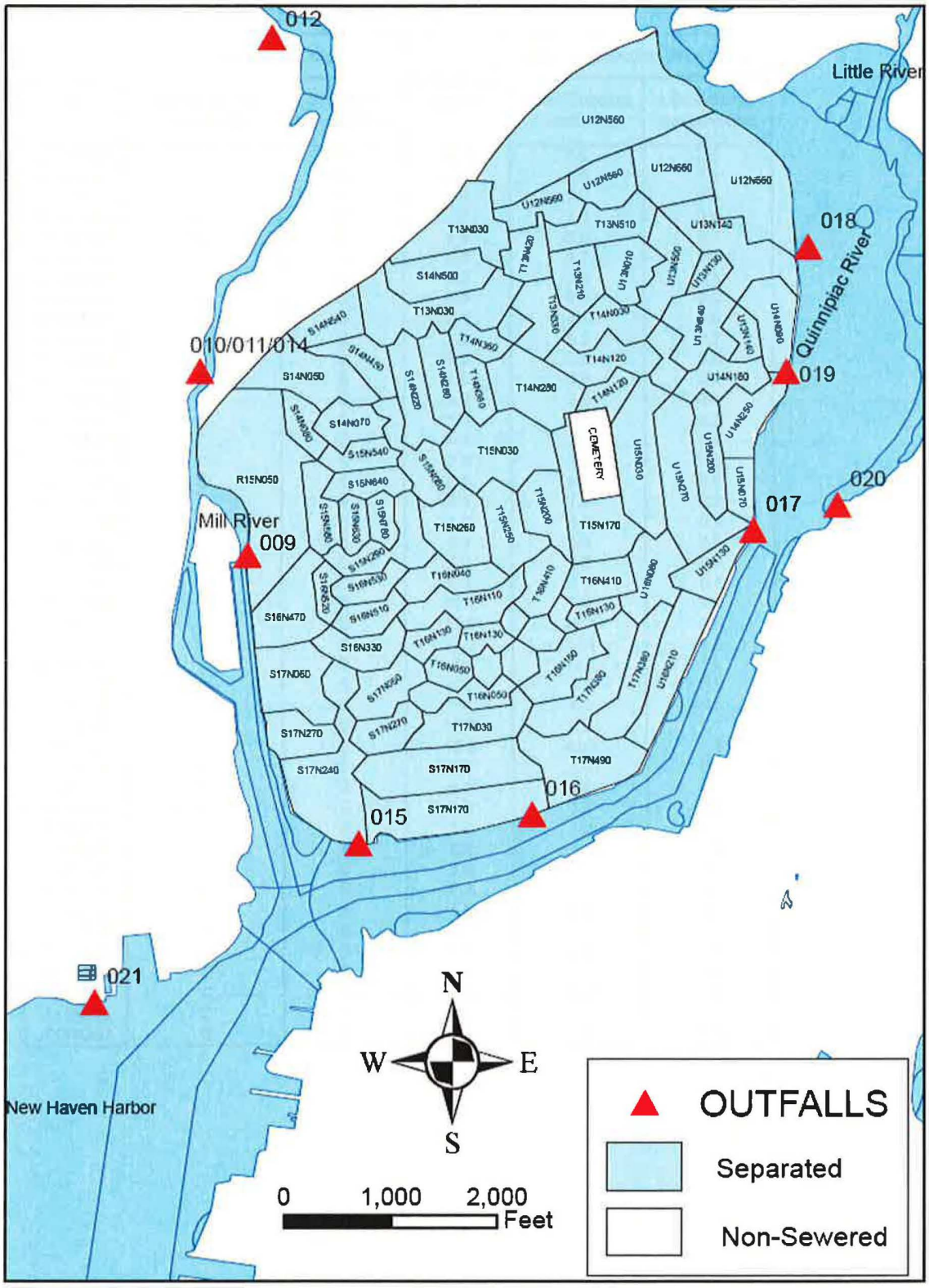


EXHIBIT 24

Planned Fair Haven Sewer Separation Project

Catchment ID	Catchment Status		Actual Area (acres)	Modeled Effective Area (acres)	
	2007 Existing Conditions	LTCP Study Assumption		2007 Existing Conditions	LTCP Study Assumption
T15N250	C	S	7.5	5.7	0.8
T15N260	C	S	8.6	6.4	0.9
T16N040	C	S	6.2	4.7	0.6
T16N050	C	S	3.4	2.5	0.3
T16N050	C	S	4.6	3.6	0.5
T16N110	C	S	7.7	5.8	0.8
T16N120	C	S	1.3	1.0	0.1
T16N130	C	S	1.3	1.0	0.1
T16N130	C	S	2.4	1.8	0.2
T16N130	C	S	3.5	2.6	0.3
T16N130	C	S	2.4	1.8	0.2
T16N130	C	S	2.7	2.1	0.3
T16N130	C	S	2.6	1.9	0.3
T16N150	C	S	7.1	5.4	0.7
T16N220	C	S	1.9	1.4	0.2
T16N410	C	S	5.2	3.9	0.5
T16N410	C	S	5.4	4.0	0.5
T17N030	C	S	9.1	6.8	0.9
T17N380	C	S	8.3	6.2	0.8
T17N380	C	S	10.9	8.2	1.1
T17N490	C	S	13.0	9.7	1.3
U12N560	P	S	37.0	9.2	3.7
U12N560	P	S	17.5	4.4	1.6
U12N560	P	S	10.3	2.6	1.0
U12N560	P	S	6.0	1.5	0.6
U12N560	P	S	5.6	1.4	0.6
U13N010	P	S	6.5	1.6	0.6
U13N130	P	S	2.5	0.6	0.3
U13N140	P	S	12.1	3.0	1.2
U13N140	P	S	3.0	0.8	0.3
U13N500	P	S	7.5	1.9	0.8
U13N540	P	S	3.4	0.8	0.3
U13N640	P	S	8.4	2.1	0.8
U14N090	P	S	7.5	1.9	0.8
U14N180	P	S	5.9	1.5	0.6
U14N250	C	S	7.2	5.4	0.7
U15N030	C	S	12.6	9.5	1.3
U15N070	C	S	3.5	2.6	0.3
U15N130	P	S	5.4	1.3	0.5
U15N200	C	S	6.7	5.0	0.7
U15N270	C	S	14.0	10.5	1.4
U16N060	C	S	7.6	5.7	0.8
U16N210	P	S	10.4	2.6	1.0
Total			651.0	379.3	65.1

The LTCP Scenario II Study model representation of the pump station simulated three (3) 13,500-gpm variable speed differential head pumps for a maximum capacity of 58.3 mgd, as shown in Exhibit 25. The 2007 Existing Condition and LTCP Scenario I hydraulic models were configured to represent the 3+1 operation with actual capacities totaling 15,400 gpm (22.2 mgd) and differential head curves imported into the model database. Copies of the pump curves are provided in Attachment 1.

Barnes and Quinnipiac Pump Stations

These pump stations were recently renovated. The Barnes Pump Station has two submersible pumps with a design capacity of 1,400 gpm each (OMI, 2006b). The pumps are operated in a 1+1 manner, with one of the pumps available for operation and one held in reserve for emergency situations. Therefore, the pump station has a maximum capacity of 1,400 gpm (2 mgd). The Quinnipiac Pump Station has four submersible pumps with a design capacity of 1,660 gpm each (OMI, 2006a). The pumps are operated in a 3+1 manner, with three of the pumps available for operation and one held in reserve for emergency situations. Therefore, the pump station has a maximum capacity of 5,000 gpm (7.2 mgd).

Since the stations were renovated, the LTCP Study model representation was replaced with new configurations for both pump stations in the 2007 Existing Condition hydraulic model. The Barnes Pump Station is simulated with a single 1,400-gpm (2 mgd) pump using differential head curves imported into the model database. The Quinnipiac Pump Station is simulated in the 3+1 configuration with a maximum capacity of 5,000 gpm (7.2 mgd) and differential head curves imported into the model database. Copies of the pump curves for both stations are provided in Attachment 1

Morris Cove Pump Station

The pumps at the Morris Cove Pump Station were recently replaced and new pump curves were obtained. The pump station has five pumps with a capacity of 3,130 gpm each (OMI, 2007). The pump curves were imported into the 2007 Existing Condition hydraulic model as differential head curves. Copies of the pump curves for this station are provided in Attachment 1.

Cross Connections

The New Haven collection system contains several cross connections within the collection between the stormwater and sanitary sewers. The STCP and LTCP recommended to identify, inspect, and document the cross connections, with the intention of eliminating them if feasible and necessary. The recommended actions have been taken and some of these cross connections have been eliminated by projects implemented since short- and long-term planning. Some cross connections were not modeled during the original planning effort while others were discovered late in the planning effort. Based on the information compiled from the Authority, only two model modifications were necessary to construct the 2007 Existing Condition hydraulic model, described as follows.

Barnes Pump Station

The Barnes Pump Station had a 6-inch overflow pipe connecting the pump station an adjacent 15-inch stormwater sewer that discharges to the Quinnipiac River. The CSO outfall is designated 029. The 6-inch overflow pipe connecting the pump station to the stormwater sewer was removed during the Barnes Avenue and Quinnipiac Avenue Pumping Stations project (Metcalf & Eddy, 2005). As-built plans confirm the modifications. The overflow was removed from the 2007 Existing Condition model.

Quinnipiac Pump Station

The Quinnipiac Pump station had a connection to the stormwater system via an overflow pipe to a stormwater sewer that discharges to the Quinnipiac River. The CSO outfall is designated 030. The 24-inch overflow pipe and 24-30-inch RCP stormwater pipes connecting the pump station influent chamber to the stormwater collection system were removed (Metcalf & Eddy, 2005). As-built plans confirm the modifications. The overflow was removed from the 2007 Existing Condition model.

Cross Connections at CSO 013

This cross connection has been eliminated from the 2007 Existing Condition hydraulic model to reflect existing conditions.

Other Model Updates

Truman Tank

The construction of The Truman Tank was completed in 2006. The tank was not simulated using models during long-term control planning previously. However, subsequent modeling added a representation of the CSO storage tank for planning and design simulations using design documents produced prior to construction. Following the construction, changes were made to the bending weir elevation design. Therefore, the model representation of the weir crest elevation was adjusted to 4.80 feet to match as-built plans.

EXHIBIT 25

Design Data for Major Pump Stations for LTCP Scenarios I and II

Model Conditions	Model Element	Pump Design Data			Quantity	Max Design Capacity (mgd)	Peak Inflow to WPAF (mgd)
		Flow (gpm)	Pump Speed (rpm)	Total Dynamic Head (feet)			
LTCP I	EAST PS	12,000	705	98	3+1	51.8	147
	BLVD PS	11,000	706	207	3+1	47.5	
	UNION PS	Existing			3+1	22.2	
LTCP II	EAST PS	12,000	705	98	3+1	51.8	187
	BLVD PS	11,000	706	207	3+1	47.5	
	UNION PS	13,500	706	171	3+1	55.3	

Hydraulic Model Version Tracking

Exhibit 26 provides the name and description for the collection system hydraulic model. These model files simulate 2007 Existing Conditions, LTCP Scenario I, and LTCP Scenario II.

EXHIBIT 26
New Haven Collection System Model Files

Filename	Description
NewHaven_CS_Model.MPR	Mouse project file.
NewHaven_CS_Model.HGF	Mouse hydrology file.
NewHaven_CS_Model .UND	Mouse network file.

Summary

The Authority's collection system hydraulic model was originally developed in 1998 to support the CSO LTCP and calibrated as part of the LTCP development. This planning-level model is documented in LTCP technical memorandums. With plan implementation proceeding, the modeling framework was out-of-date with respect to changes that were made to the collection system but not simulated in the model. A data request was submitted to the Authority tracking and compiling information on STCP and LTCP implementation, other collection system projects, or operational information related to collection system performance. Updated information and data were compiled on sewer separation projects, pump stations, cross connections, CSO regulators and outfalls, and the construction and operation of the Truman Tank. A 2007 Existing Condition model was then constructed to represent the Authority's collection system as it operates currently. Moreover, LTCP Scenarios I and II were also added to evaluate the long-term CSO control plans.

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OMI. (2006a). Quinnipiac Avenue Pump Station New Haven Water Pollution Control Authority Operations Manual.

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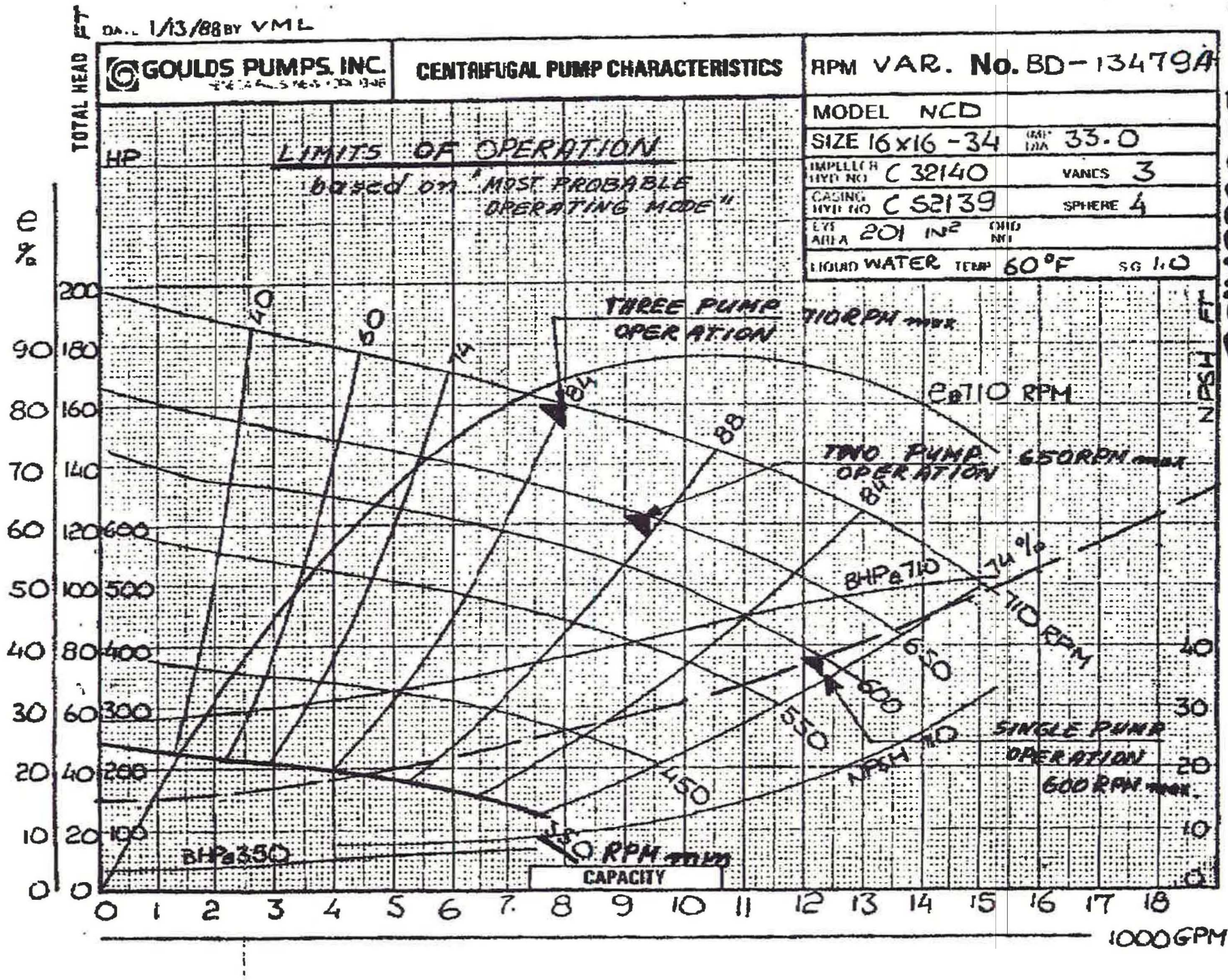
DATE 1/13/88 BY VML
GOULDS PUMPS, INC.
CENTRIFUGAL PUMP CHARACTERISTICS
RPM VAR. No. BD-13479A
MODEL NCD
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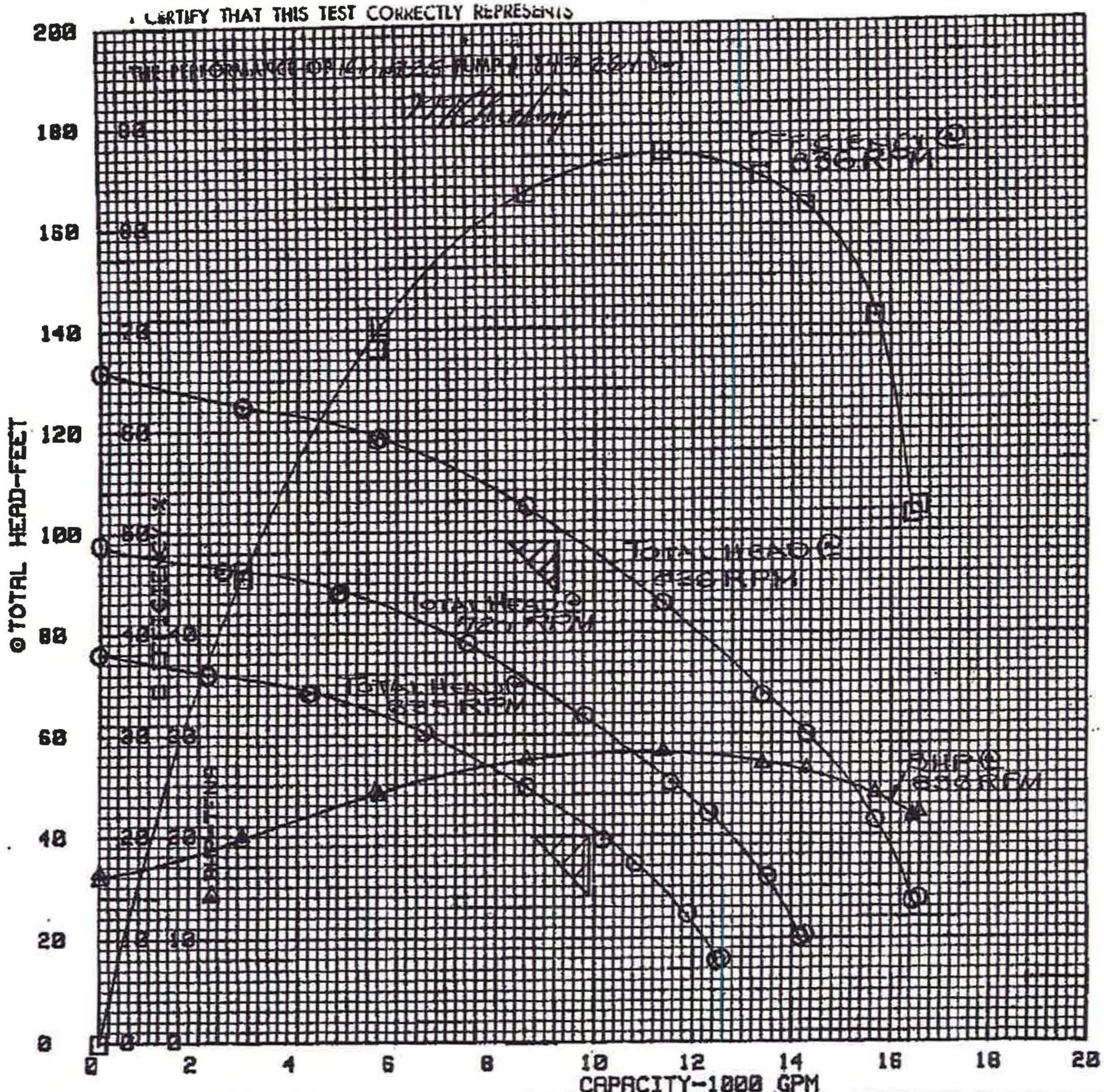
IMPELLER HYD NO C 32140
CASING HYD NO C 52139
EYE AREA 201 IN²
LIQUID WATER TEMP 60°F
SG 1.0
VANES 3
SPHERE 4
HP
LIMITS OF OPERATION
based on "MOST PROBABLE OPERATING MODE"
TOTAL HEAD FT
EFF %
THREE PUMP OPERATION
TWO PUMP OPERATION
SINGLE PUMP OPERATION
BHP@710
BHP@350
NPSH
710 RPM
650 RPM
600 RPM
350 RPM
CAPACITY
1000 GPM
FT HEAD
BOULEVARD
BOSTON SALES OFFICE
P.8

GNH0016-046



WORTHINGTON DIVISION
McGRAW EDISON Co.
PUMP TEST DATA

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718.0	2470	92.0	127.3	45.5
718.0	4765	87.6	155.4	68.1
718.0	7410	77.5	174.3	83.2
719.0	9800	63.5	180.0	87.3
718.0	11520	50.1	171.0	84.5
718.0	12270	44.2	167.5	81.8
718.0	13492	31.6	152.6	71.0
719.0	14257	20.6	141.0	52.5
718.0	14139	20.1	138.0	51.7
719.0	14130	20.0	138.3	51.6
716.0	4843	87.7	152.4	70.4
720.0	2470	92.5	124.6	46.4
719.0	0	97.4	100.6	0.0

SP GR:1

EAST STREET

CASING DATA

MATERIAL	FINISH	TONGUE
C.I.	—	—

IMPELLER DATA

MATERIAL	FINISH	DISC. TIPS
C.I.	#2	—

PATT. NO.	COMB. NO.	DIA.
UB5510B	B-5	25.00

				DATE	STG		TEST DRIVER	VENTURI	PLOTTED RPM	CURVE NO.
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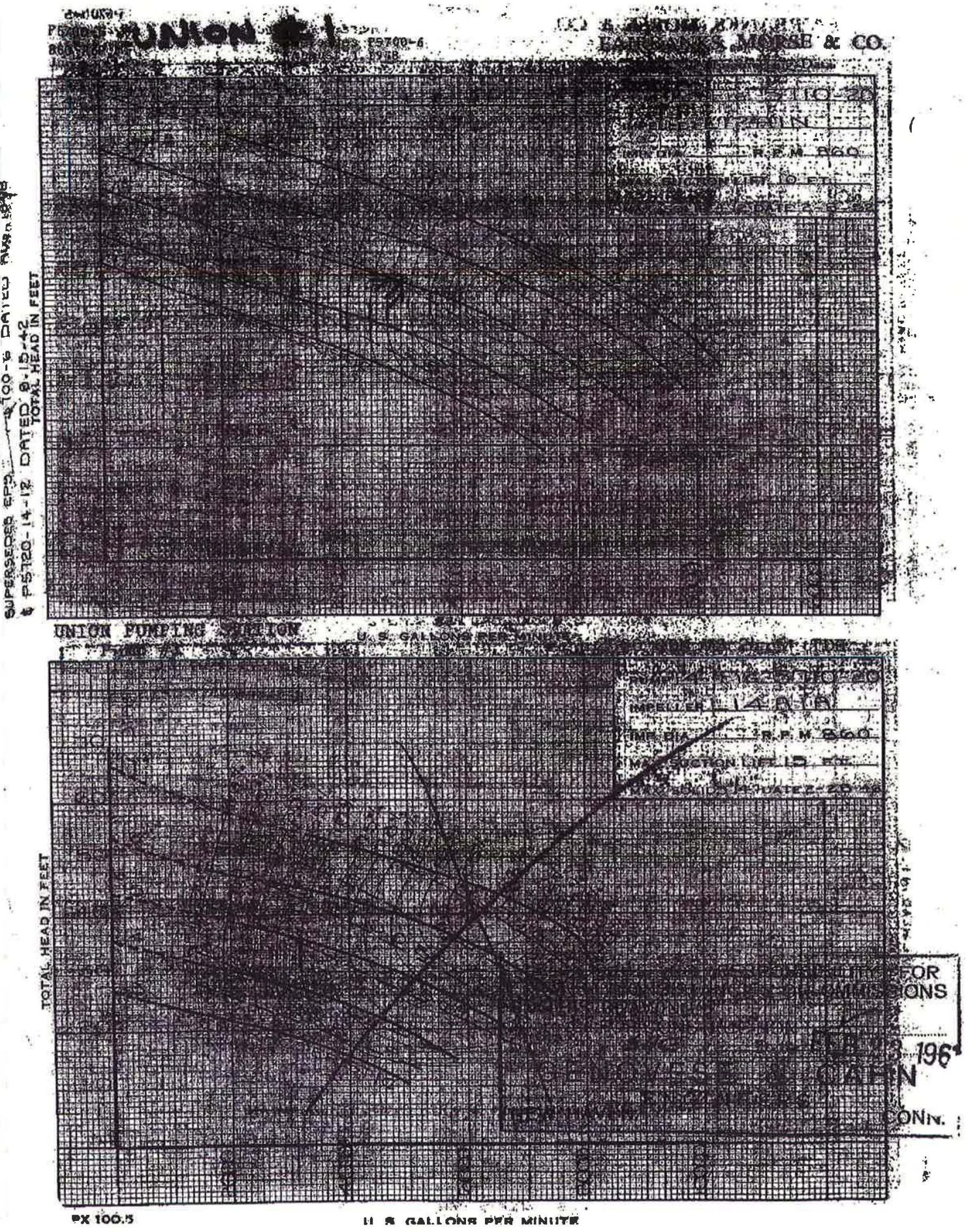
GNH0016-047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BATCHELDER, MORSE & CO.
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& PS720-14-12 DATED 9-15-42
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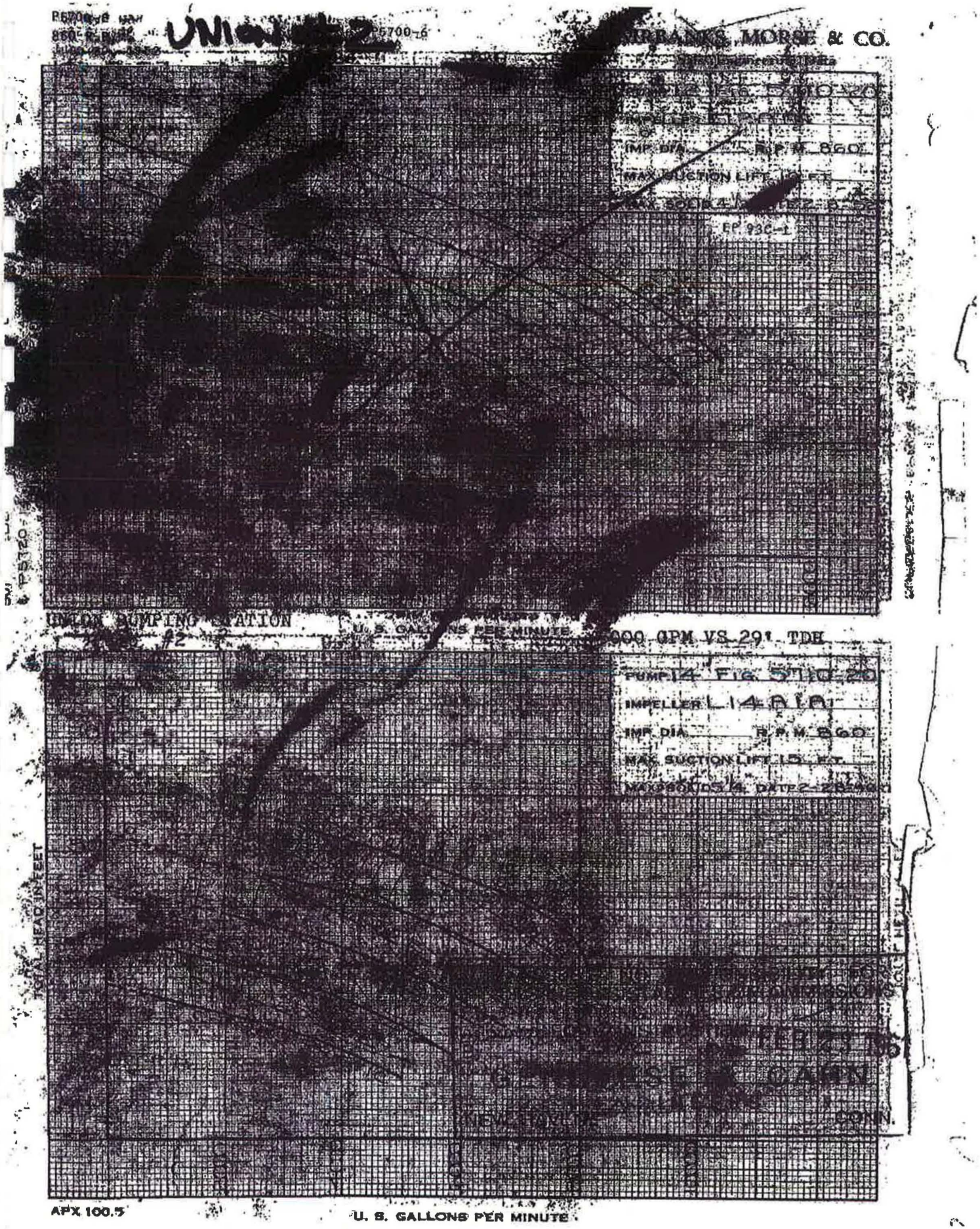
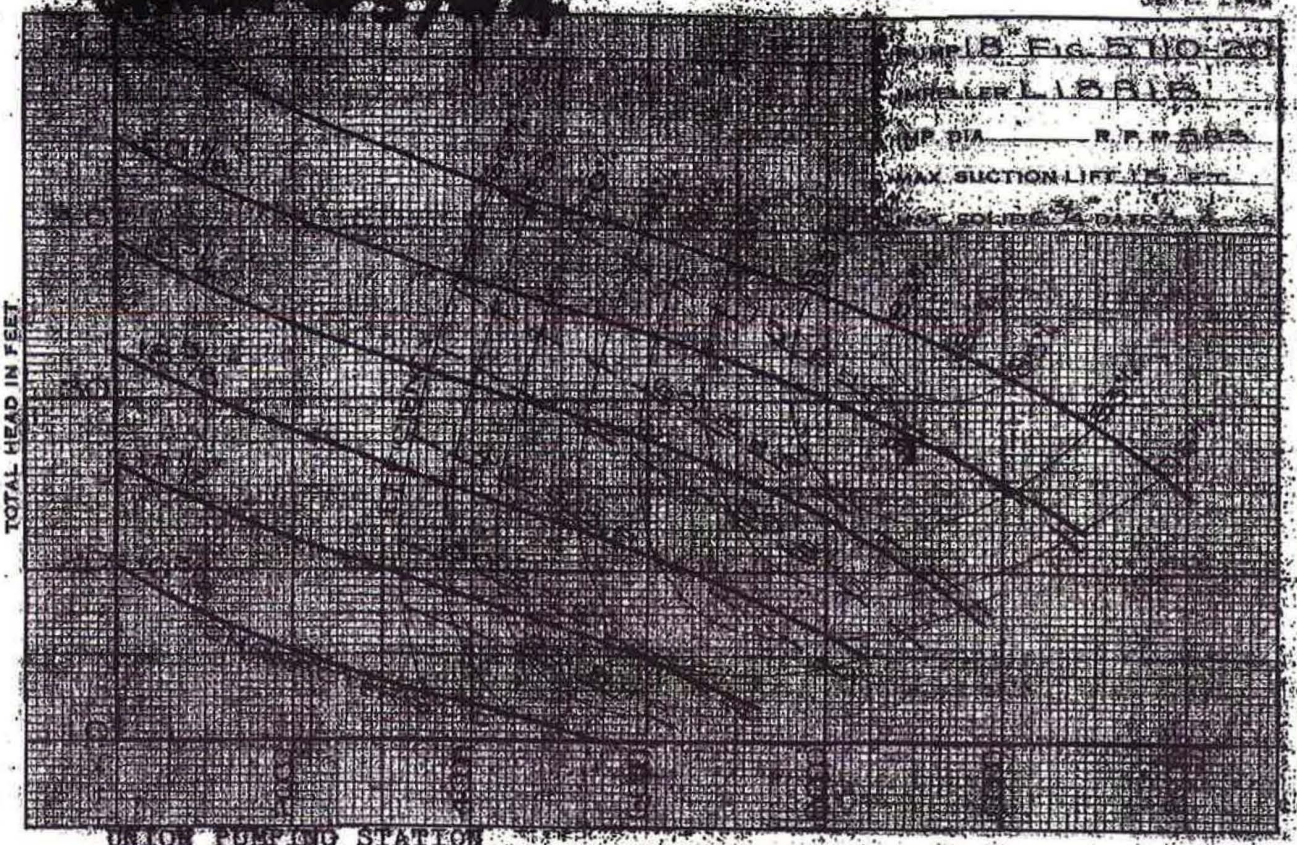
UNION PUMPING STATION
U.S. GALLONS PER MINUTE
TOTAL HEAD IN FEET
PX 100.5
U. S. GALLONS PER MINUTE

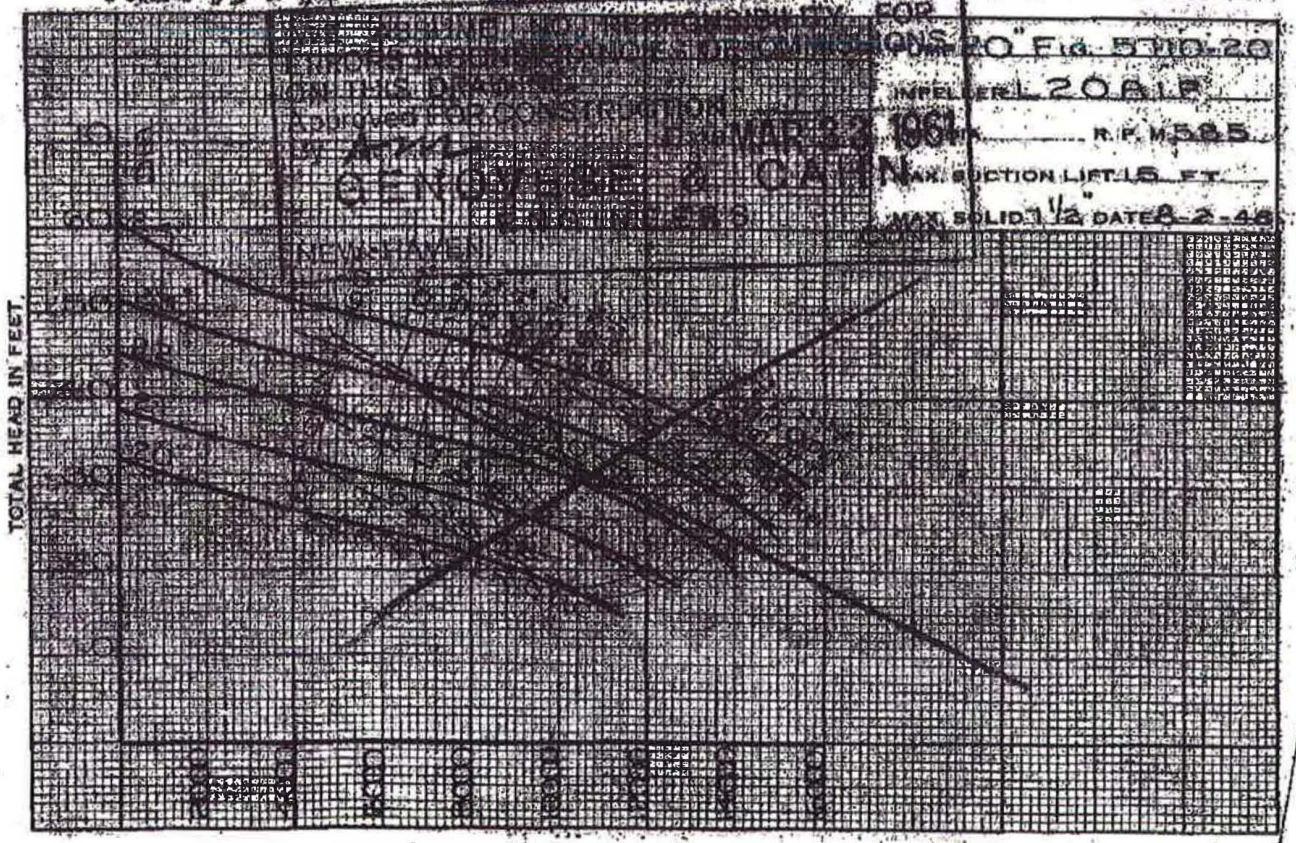

FAIRBANKS, MORSE & CO.
IMP. DIA.
R.P.M. 860
MAX. SUCTION LIFT
EP 93C-1
#2
U. S. GALLONS PER MINUTE
000 GPM VS 29' TDH
PUMP 14 Fig. 5710-20
IMPELLER 14-A1P1
IMP. DIA.
R.P.M. 860
MAX. SUCTION LIFT 15 FT.
TOTAL HEAD IN FEET
APX 100.5
U. S. GALLONS PER MINUTE

Supersedes P5700-13
March, 1946.

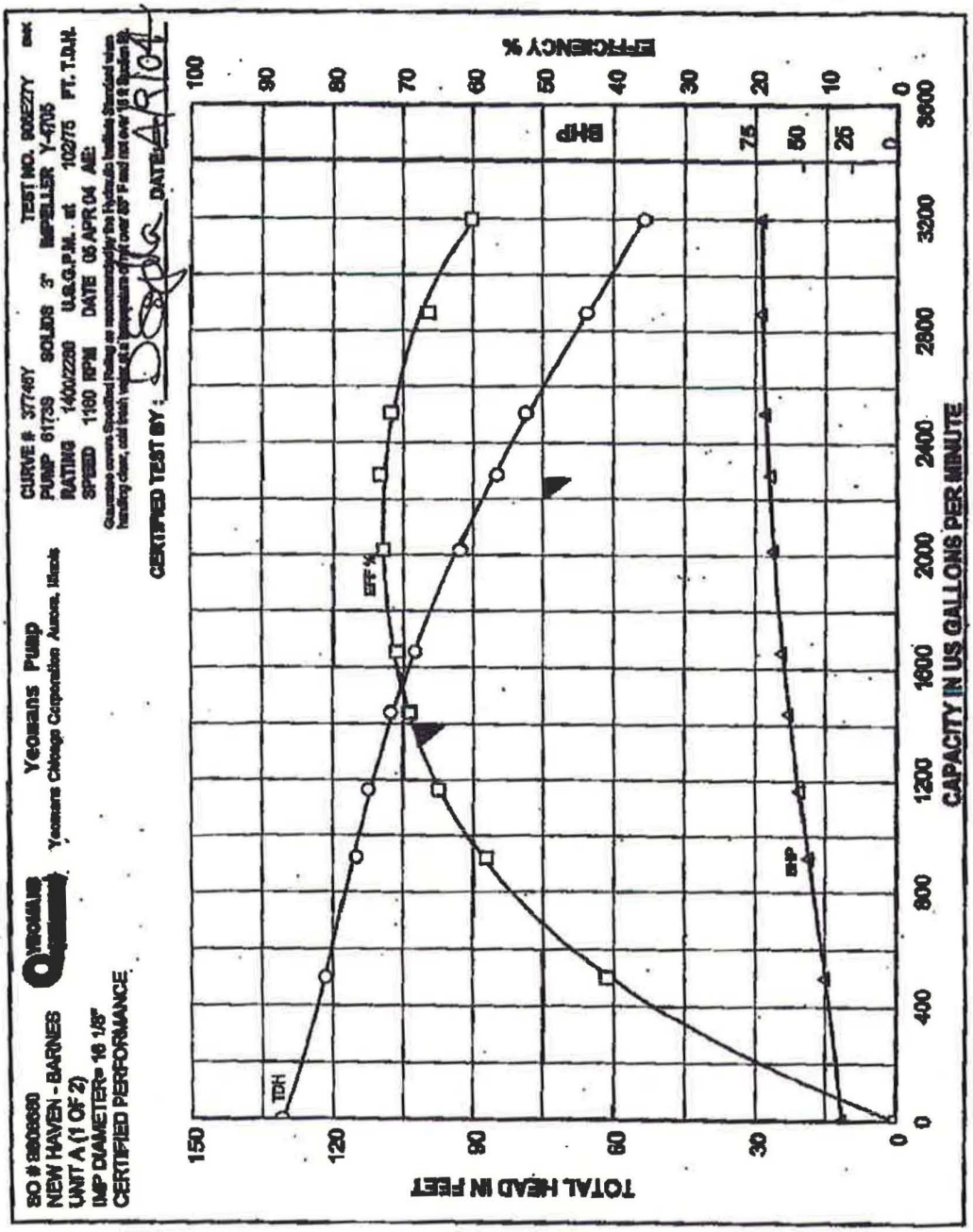


UNION PUMPING STATION
PUMPS #3 & #4

9000 GPM @ 28' TDH



BARNES


SO # 8808660
NEW HAVEN - BARNES
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CERTIFIED PERFORMANCE
Yeomans Pump
Yeomans Chicago Corporation Aurora, Illinois
CURVE # 377469Y
PUMP 61733 SOLIDS 3" IMPELLER Y-4705
RATING 1400/2260 U.S.G.P.M. at 102/75 FT. T.D.H.
SPEED 1160 RPM DATE 05 APR 04 AE:
CERTIFIED TEST BY :
DATE 4/8/04
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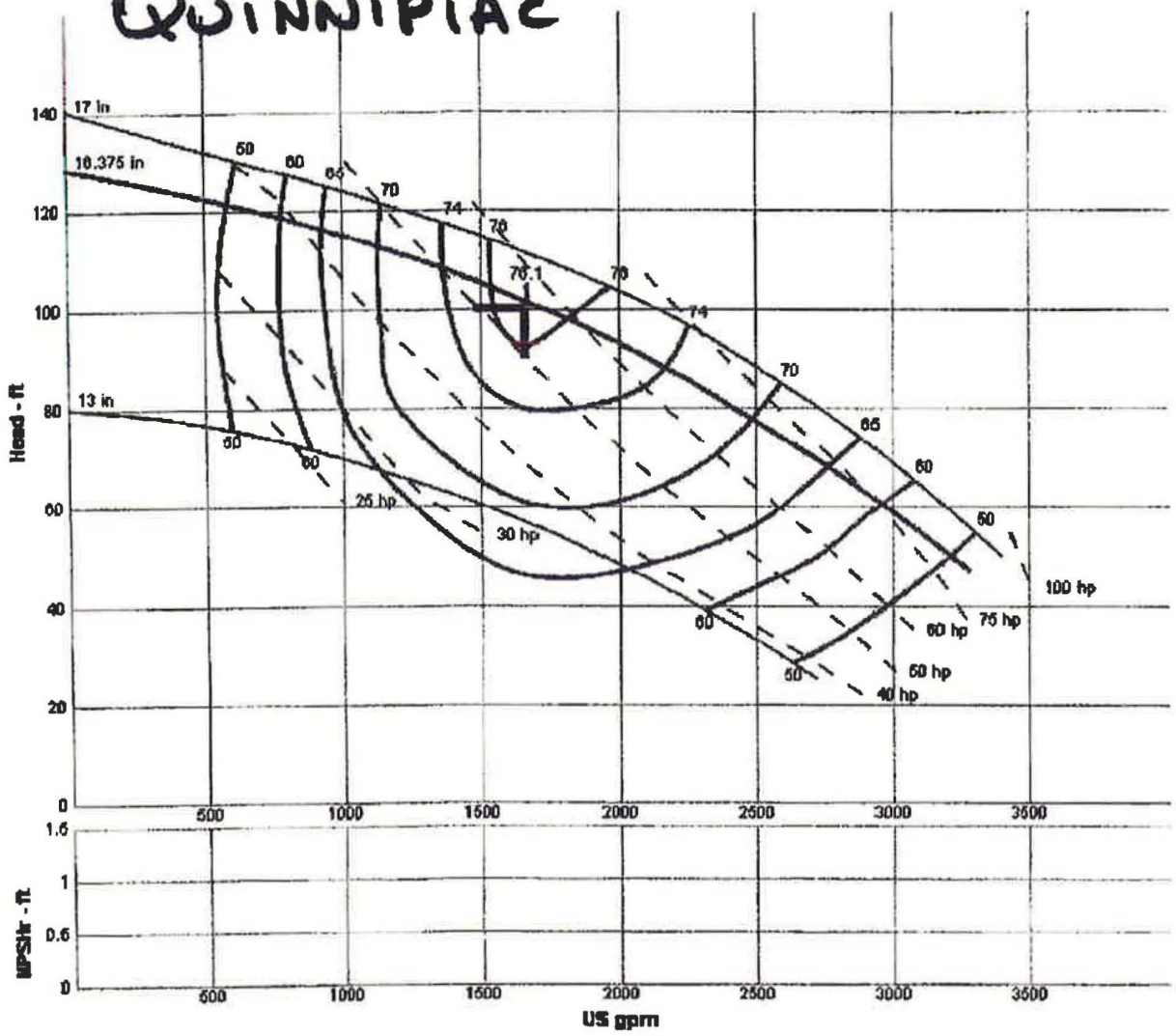
TDH
EFF %
BHP
TOTAL HEAD IN FEET
EFFICIENCY %
CAPACITY IN US GALLONS PER MINUTE

QUINNIPIAC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13 in
50
60
65
70
74
76
76.1
25 hp
30 hp
40 hp
50 hp
60 hp
75 hp
100 hp
Head - ft
NPSHr - ft
US gpm
0
20
40
60
80
100
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1000
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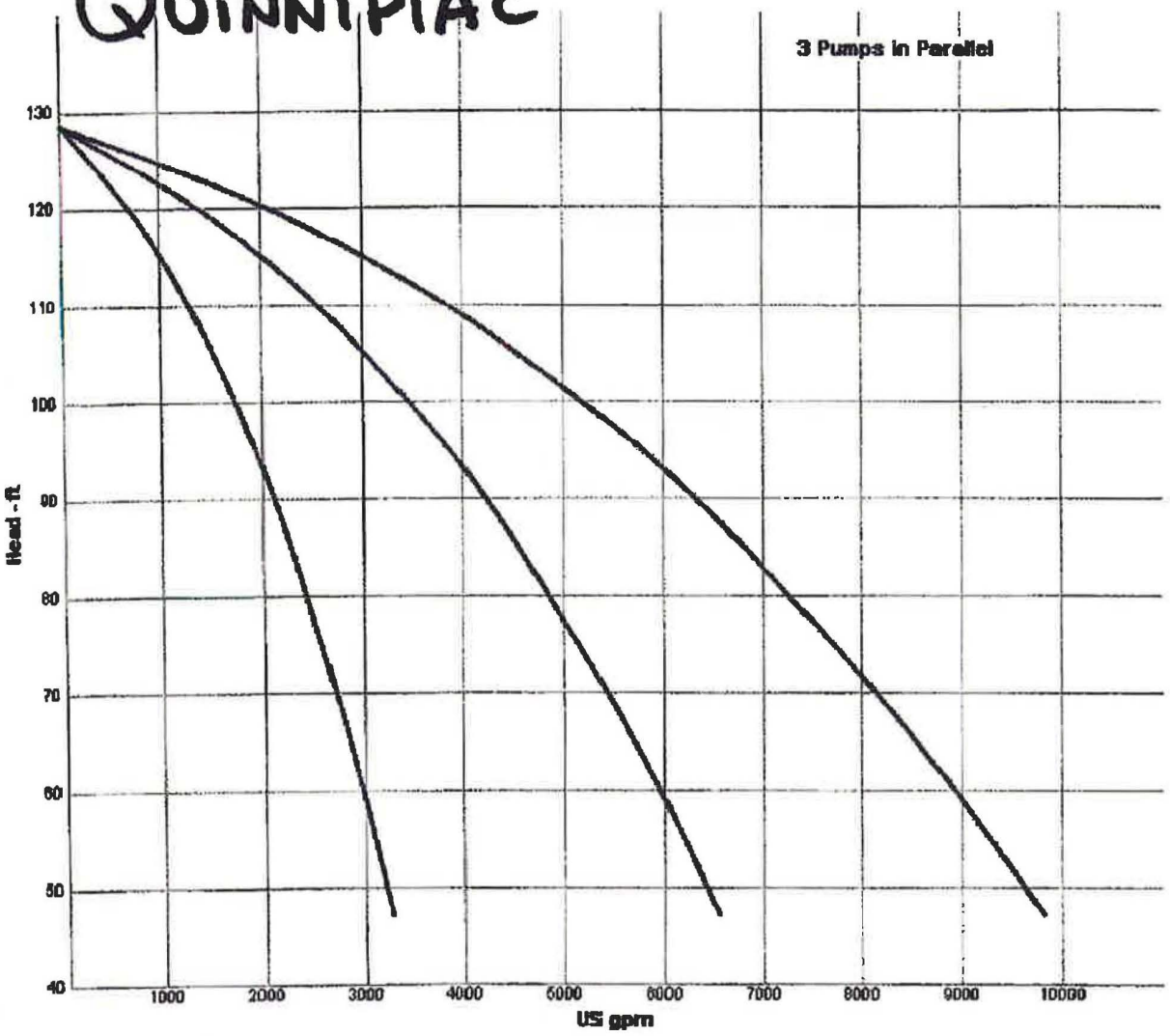
3000
3500

QUINNIPIAC



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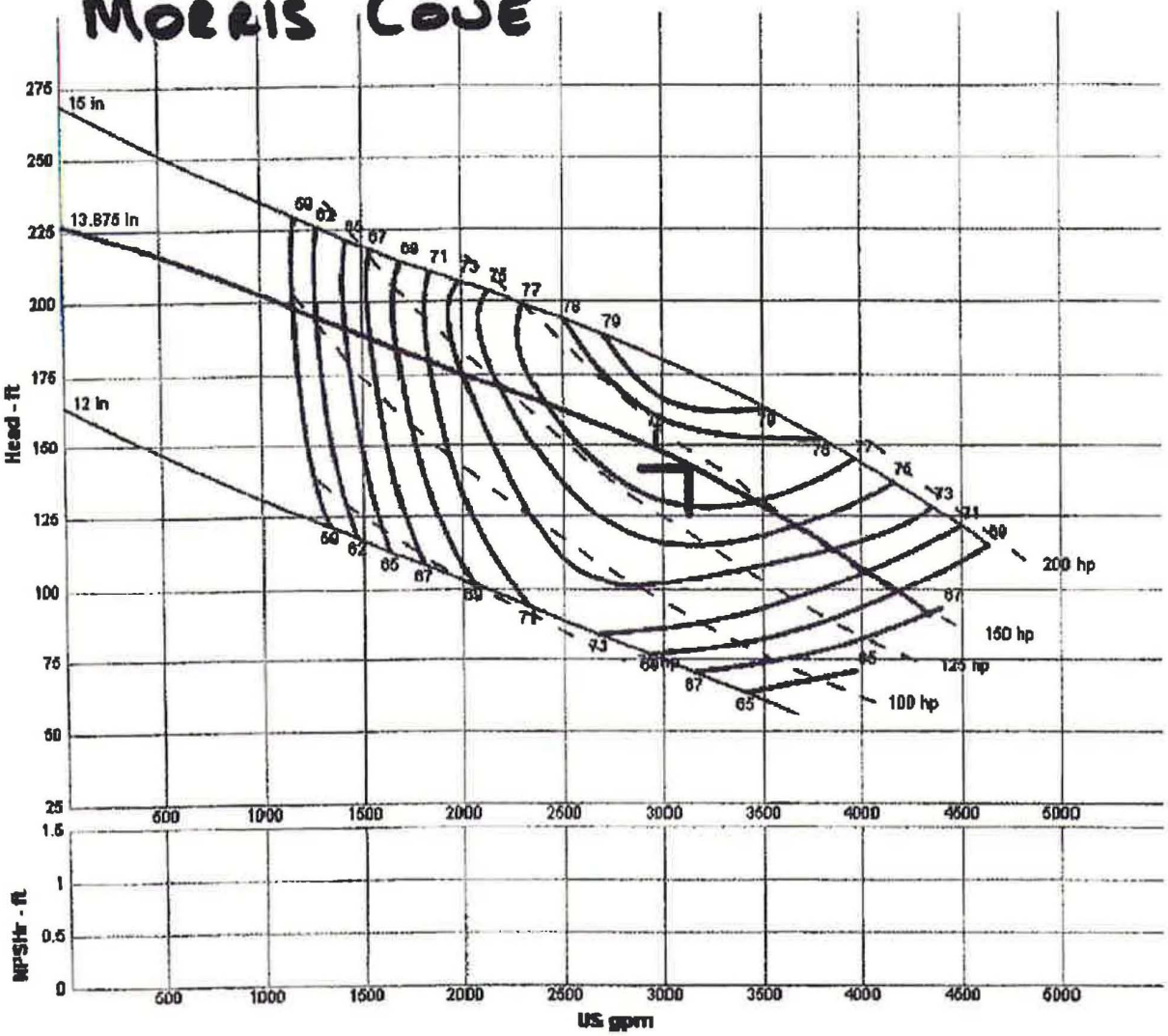
MORRIS COVE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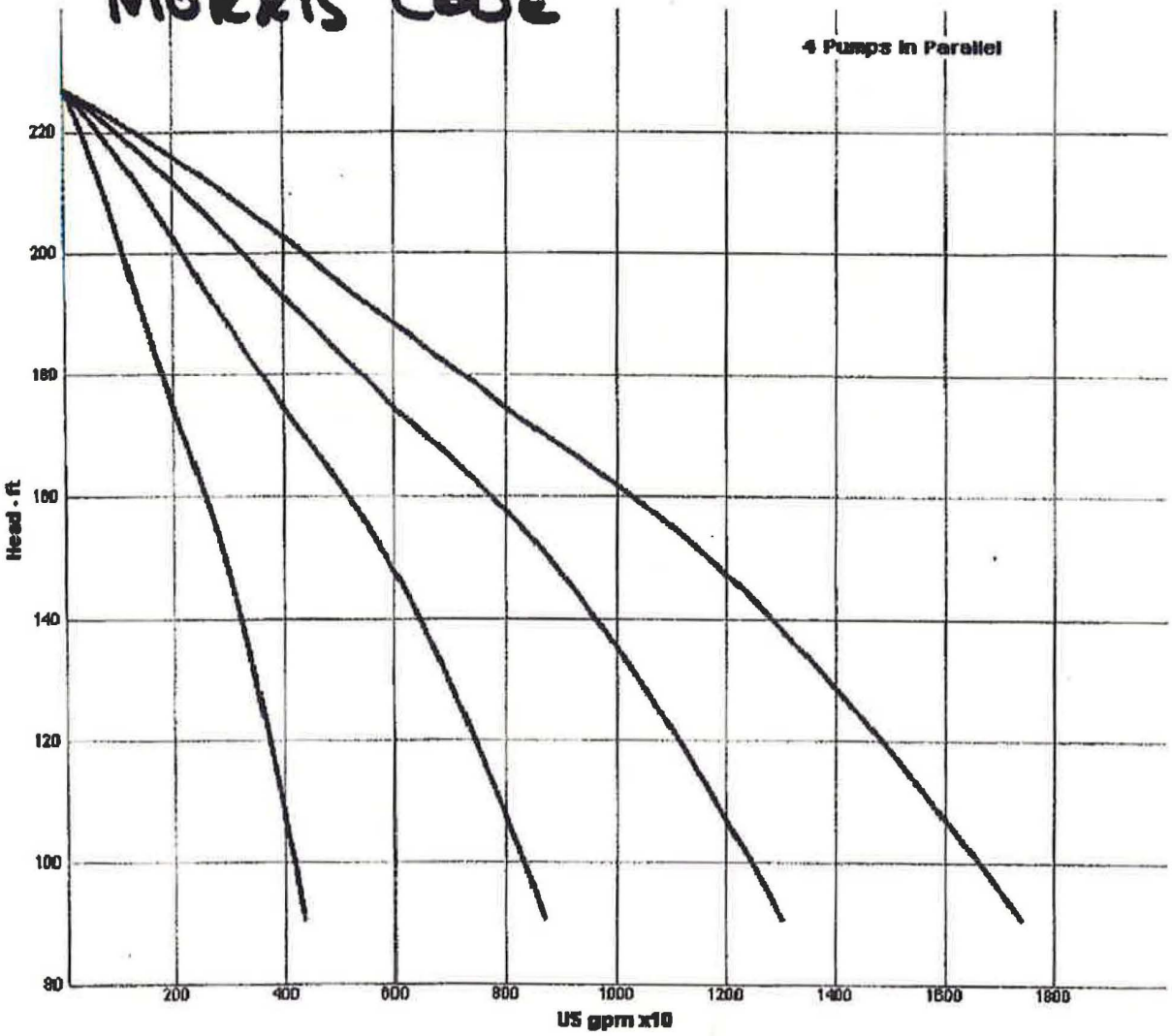
Head - ft
NPSHr - ft
US gpm
200 hp
150 hp
125 hp
100 hp

MORRIS COVE



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6/28/2007

Task Order 2A: Final Flow Meter Locations

TO: New Haven Flow Metering Project Team

FROM: Tony Parolari/CH2M HILL

DATE: April 3, 2007

REVISED DATE: April 17, 2007

PROJECT NUMBER: 350590

Final Flow Metering Locations

The Hydraulic Model Update, Flow Monitoring, Model Verification, and Hydraulic Analyses Task Order 2a is intended to update the Greater New Haven Water Pollution Control Authority's (the Authority) hydraulic model to represent existing conditions (2007). An updated and verified hydraulic model will allow the Authority to verify the recommendations from the Wet Weather Preliminary Engineering Project, confirming the maximum pumping capacity for the Boulevard and East St Pump Stations and the appropriate treatment capacity at the East Shore WPAF. Additionally, a hydraulic model update fits into the Authority's long-term vision for modeling and alternatives evaluation – supporting planning and design activities related to implementation of the Long-term Control Plan.

In the Scope of Services for this task order, a preliminary list of flow metering locations was proposed to support model verification activities. Monitoring priorities were discussed at the project kick-off meeting held March 27, 2007. The flow meter list has been revised accordingly to reflect these priorities and better meet the needs of the Authority. The following priorities have been established for flow meter locations:

1. Choose meter locations to provide the most information pertinent to the ongoing Wet Weather Preliminary Engineering Project. This project is focused on system improvements at the Boulevard and East Street Pump Stations, as well as increased hydraulic and process capacity at the East Shore Water Pollution Abatement Facility (WPAF).

2. Meter at least two of the city boundary locations previously metered by the Authority. Boundary meters will provide information regarding wet weather peaks from surrounding communities.

3. Provide metering throughout the collection system, including Fair Haven.

Table 1 summarizes the updated meter locations and the data to be collected at each site. The meters are also shown on the attached system map (Figure 1).

CH2M HILL and ADS Environmental Services reviewed the metering locations and identified suitable manholes for installation on April 10 and 11, 2007. Table 1 and Figure 1 have been updated to reflect these site investigations. Meter installations are anticipated to begin on April 23, 2007.

TABLE 1.
Final Flow Metering Locations

Location	Meters Deployed	Data Type
Boulevard Interceptor (near OF 024)	1	Interceptor
Boulevard Interceptor (near OF 002)	1	Interceptor
Boulevard Interceptor (near OF 003)	1	Interceptor
Boulevard Interceptor (near OF 004)	1	Interceptor
Boulevard Interceptor (near OF 005)	1	Interceptor
Boulevard Interceptor (near OF 006)	1	Interceptor
Thorpe Drive / Brookside Drive (NH-12, Hamden)	1	External Inflow
East Street Interceptor (near OF 021)	1	Interceptor
East Street Interceptor (near East/Ives)	1	Interceptor
East Street Interceptor (near OF 010)	1	Interceptor
East Street Interceptor (near OF 012)	1	Interceptor
East Street Interceptor (near OF 013)	1	Interceptor
East Street Interceptor (near OF 014)	1	Interceptor
East Street Interceptor (Canal Street)	1	Interceptor
Winchester Avenue (NH-04, Hamden)	1	External Inflow
East Rock Road / Park Drive (NH-11, Hamden)	1	External Inflow
Fair Haven (near OF 009)	2	Interceptor (upstream and downstream of regulating structure)
Fair Haven (near OF 015)	1	Interceptor
Fair Haven (near OF 016)	1	Interceptor
Fair Haven (near OF 017)	1	Interceptor
Fair Haven (near OF 018)	1	Interceptor
Fair Haven (near OF 019)	1	Interceptor
Barnes Quinnipiac Interceptor	1	Interceptor
Woodward/Lighthouse/Morris Cove Interceptor	1	Interceptor
Total	25	

The temporary flow metering program will also include three (3) rain gauges, to be placed at locations previously used during LTCP development: Edgewood, Boulevard Pump Station, and Blatchley. As discussed below, CDM has installed a meter at Boulevard Pump Station for the Union Street Pump Station study. It is assumed that this rain gauge will be removed prior to the end of the Task Order 2A metering study. Therefore, CH2M HILL will install a meter at this location to capture rainfall data for the entire metering period.

Existing Flow Meter and Rain Gauge Locations

The following flow meters and rain gauges are currently operated and maintained in the New Haven collection system:

1. **Union Street Pump Station** – Currently, CDM is conducting a flow metering study at the Union Street Pump Station. Five (5) flow meters and two (2) rain gauges have been deployed for this study. Table 2 summarizes these locations. Data from this study will be used to support the hydraulic model verification.

2. **Pump Station SCADA** - The Boulevard, East Street, and Morris Cove Pump Stations are equipped with flow meters and SCADA. Electronic data records can be obtained from OMI.

3. **Long-term Rain Gauges** – A long-term rain gauge is located at Tweed Airport, near the East Shore WPAF. Data from this gauge can be obtained from the National Climatic Data Center. Additionally, the Regional Water Authority (RWA) maintains several rain gauges in the area – Whitney, South Cheshire, Dawson, Wepawaug, Saltonstall, and Gaillard.[1] Data from these gauges can be obtained from RWA.

TABLE 2.
Flow Meter and Rain Gauge Locations for Union Street Pump Station Study (CDM)

Location	Meters Deployed	Data Type
Water Street / Union Street (CDM1)	1	Flow Meter
George Street / State Street (CDM2)	1	Flow Meter
Water Street / Columbus Plaza (CDM3)	1	Flow Meter
George Street / Temple Street (CDM4)	1	Flow Meter
South Frontage Road (CDM5)	1	Flow Meter
East Street Pump Station	1	Rain Gauge
Boulevard Pump Station	1	Rain Gauge

[1] Several of these rain gauges are located in suburban areas surrounding the City of New Haven and are not identified on the attached map.

Greater New Haven Water Pollution Control Authority

Wet Weather Capacity Improvements – Hydraulic Model Update

Short-Term Flow Monitoring Program

PREPARED FOR: GNHWPCA

PREPARED BY: CH2M HILL

DATE: August 16, 2007

PROJECT NUMBER: 350590

Introduction

During recent modeling activities to support Preliminary Engineering for Wet Weather Capacity Improvements, it was found that the planning-level hydraulic modeling scenarios previously developed to support the Greater New Haven Water Pollution Control Authority ("the Authority") Long-term Control Plan (LTCP) do not accurately reflect the collection system as it exists today. In the time since development of the LTCP model in 1997, several changes have occurred in the New Haven collection system - including sewer separation projects, regulator modifications, and conventional growth and development. The Authority is conducting a Hydraulic Model Update task to update the model, verify that it accurately represents existing conditions, and to have a more current tool for evaluating engineering alternatives for its Wet Weather Preliminary Engineering project.

The Authority's hydraulic model was updated to reflect 2007 existing conditions in the collection system, as described in the August 1, 2007 *Hydraulic Model Improvements* technical memorandum. Concurrent to the Hydraulic Model Improvements effort, a short-term flow-monitoring program was conducted by the Authority. The purpose of the program was to collect collection system flow data that can be used to verify that the Authority's hydraulic model accurately simulates existing dry and wet weather conditions in the system, considering that many elements of its short- and long-term control plans have been implemented.

This technical memorandum describes technical work efforts performed in the Short-Term Flow Monitoring Program subtask to collect collection system rainfall and flow data. A summary of the monitoring effort, graphical illustrations of results, a quality assessment of the data, and caveats to its use in the subsequent model performance verification is provided herein.

Program Methodology

The objectives of the monitoring study were to develop existing conditions data on base flow and its diurnal variations during dry weather, and characterize system response during wet weather events of varying size, including storms that maximize system conveyance. For the monitoring program to be successful, a typical dry weather period and a combination of small and large storms must be observed to provide adequate data for wet-weather model verification.

The U.S. Weather Bureau Technical Paper 40 summarizes the probability of intense storms occurring at monthly intervals for the New York and New England region. In this document, it is shown that intense storms are most likely to occur between the months of May and September, with larger storms occurring more frequently later in the year. This flow monitoring program was conducted in the months of May and June 2007 to align with the Authority's design and construction project schedules.

CH2M HILL developed a flow-monitoring work plan, described in *Task Order 2A: Final Flow Meter Locations* memorandum, originally dated April 3, 2007 and revised April 17, 2007. The data quality goals of the program were to monitor rainfall in the collection system survey area and monitor flow in the collection systems at the same locations as that done during the original LTCP modeling effort. The work plan had the following elements:

- Identify three rainfall and twenty-four flow monitoring locations.
- Perform site investigations to finalize monitoring locations.
- Install rain gages and collection system velocity and depth meters.
- Monitor conditions for six weeks.
- Remove all meters and gages.

Three rain gauges were placed at locations previously used during LTCP development: Boulevard Pump Station, Edgewood, and Blatchley. Twenty-one collection system locations were selected to monitor flow in all branches of the system (CSO 009 had two sets of meters, upstream and downstream of a CSO discharge). Three boundary locations were also selected to monitor flow entering the system from regional communities. The *Task Order 2A: Final Flow Meter Locations* memorandum tabulates and illustrates the monitoring locations.

Program Execution

ADS Environmental Services was contracted to perform execute the program. CH2M HILL and ADS Environmental Services performed site inspections on April 10 and 11, 2007 to identify suitable manholes for meter installations. Site inspection data sheets are provided in Attachment 1. All rainfall and collection system monitoring devices were installed and operating by May 11, 2007. The ADS monitoring methodology is reproduced in Attachment 1. The devices were removed after six weeks, the last data was collected on June 21, 2007. ADS released a Final Report via its online services on July 23, 2007. An electronic cover letter is reproduced in Attachment 1. Preliminary data was made available to CH2M HILL and the Authority during the program. The data was finalized by ADS will remain online for one year after the program was completed.

Additional rainfall data sources were also identified and utilized during the monitoring period. Rainfall data was provided at three regional locations by the Regional Water Authority (RWA) for the May and June 2007 at their Whitney, Furnace Pond and Dawson locations. Preliminary and final rainfall data was also obtained from the National Climatic Data Center (NCDC) at Tweed Airport near the East Shore Water Pollution Abatement Facility (WPAF) for the period June 2006 through June 2007.

Additional flow monitoring data sources were also identified and utilized during the monitoring period. Data from pump station SCADA systems and the East Shore WPAF were obtained during the monitoring period. The Authority was also conducting a flow-monitoring program at its Union Street Pump Station, but that program was completed prior to the start of this program.

Program Results

The data quality objectives were to collect rainfall and collection system flow data during the six-week monitoring period sufficient to verify hydraulic model performance. The following describes the rainfall and flow monitoring data collected during the program.

Rainfall Monitoring

The objectives included monitoring several wet-weather events of varying intensity and total rainfall, with at least one event as close as possible to the two-year design storm used for LTCP development. Rainfall information was tracked during the six-week period and several events were observed. Overall rainfall data collected at all rain gages during the May 11 through June 21 monitoring period is summarized in Exhibit 1.

EXHIBIT 1
Total Rainfall Observed From May 11 through June 21, 2007 at All Gages

Location	Source	Total Rainfall (inches)
Boulevard Pump Station (RG1)	ADS	4.56
Edgewood (RG2)	ADS	2.49[1]
Blatchley (RG3)	ADS	3.98[2]
Tweed Airport	NCDC	4.31
Whitney	RWA	4.82
Furnace Pond	RWA	4.40
Dawson	RWA	5.44

(1) The Edgewood (RG2) rain gage was apparently vandalized and not operating at least on June 3-4, 2007.
(2) The Blatchley (RG3) rain gage was inoperable prior to May 19, 2007.

The Tweed Airport gage recorded 1.09 inches of rainfall in May and 3.44 inches in June. The monthly average rainfall from June 2006 through June 2007 was 4.22 inches at Tweed Airport. Despite experiencing low monthly rainfall compared to the last year, at least seven wet-weather events were identified for wet weather hydraulic model verification. A composite illustration of all rainfall observed during the monitoring period at the seven

gages is provided in Attachment 2. The seven events were compared to historical data using rainfall depth-duration-frequency curves. A rainfall depth-duration-frequency data set was developed for New Haven using data from the National Oceanic and Atmospheric Administration (NOAA) and other sources. The data is provided in Attachment 2. Exhibit 3 summarizes the wet-weather events and their return periods based on these curves.

EXHIBIT 2
Wet Weather Event Statistics and Return Periods during May 11 through June 22, 2007 Period

Event	Rainfall (inches)	Peak Intensity (inches/hour) for 60-minute time step	Return Period
May 16	0.42 to 0.88	0.38	≤ 2 months
May 18	0.23 to 0.32	0.24	< 2 months
May 31	0.09 to 0.71	0.55	< 2 months
June 3	2.17 to 2.78	0.65	Between 6 months and 2 years
June 9	0.12 to 0.40	0.32	< 2 months
June 11	0.31 to 0.48	0.40	< 2 months
June 16	0.12 to 0.37	0.17	< 2 months

Rainfall depth-duration-frequency curves for each of the seven events are provided in Attachment 2.

Flow Monitoring

Flow monitoring was conducted at 24 locations throughout the collection system. ADS submitted its final reports electronically in lieu of submitting paper copies. The following describes data availability and the percent of time that meters were recording data during the monitoring period. This is followed by commentary on each of the monitoring locations with summary flow hydrographs and data statistics on measured hydraulic elevation and velocity, and calculated flow in million gallons per day (mgd).

Data Availability

Rainfall and collection system monitoring was conducted with QA/QC goals to collect the highest level of quality data possible. ADS conducted weekly inspections of all rain gages and collection system meters to download data, service meters, and if needed correct conditions. Inspections were conducted during the monitoring period on May 16, 22, and 30, and June 6, 12, and 20. ADS had a minimum data availability or "up-time" goal of 93 percent. Exhibit 3 summarizes the data availability for each collection system monitoring location.

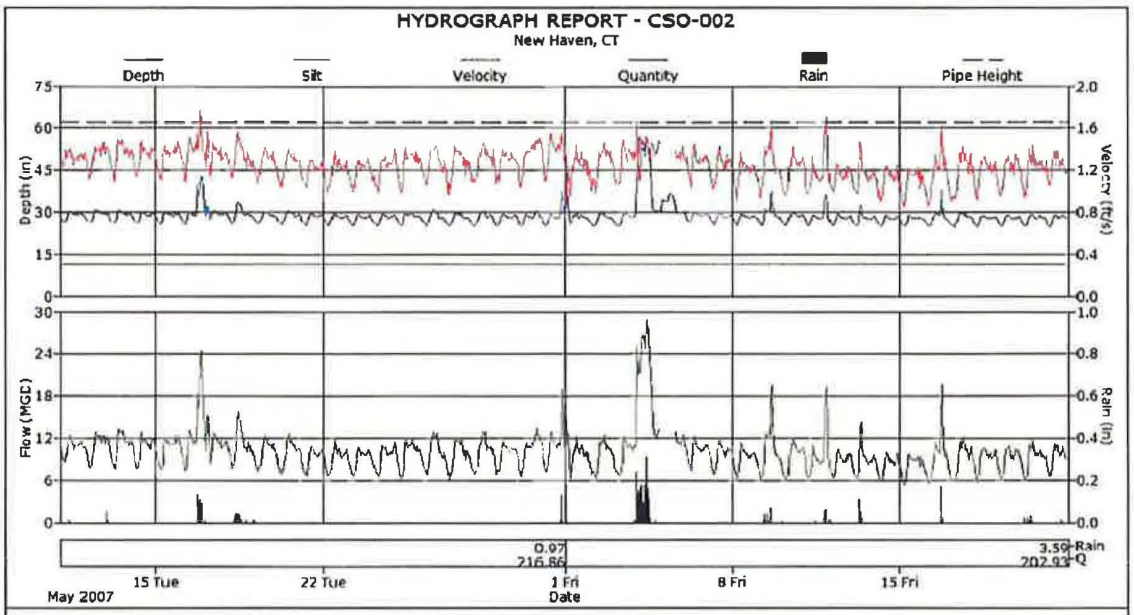
EXHIBIT 3
Data Availability for Collection System Monitoring Locations

	Data Availability (percent up-time)		
Meter Site	**Depth**	**Velocity**	**Quantity**
CSO 002	100	100	100
CSO 003	100	100	100
CSO 004	100	100	100
CSO 005	100	100	100
CSO 006	100	100	100
CSO 009	100	100	100
CSO 009A	100	100	100
CSO 010	99.95	99.95	99.95
CSO 012	100	100	100
CSO 013	99.98	99.98	99.98
CSO 014	100	100	100
CSO 015	99.88	99.88	99.88
CSO 016	100	100	100
CSO 017	n/a	n/a	n/a
CSO 018*	86.36	86.36	86.36
CSO 019	100	100	100
CSO 021	100	100	100
CSO 024	100	100	100
East/Ives	100	100	100
Canal	99.8	99.8	99.8
Ferry (Barnes-Quinnipiac)	99.95	99.95	99.95
Woodward	99.93	99.93	99.93
NH-04	100	100	100
NH-11	100	100	100
NH-12	100	100	100

* Commentary on CSO 018 is provided below.

CSO 002

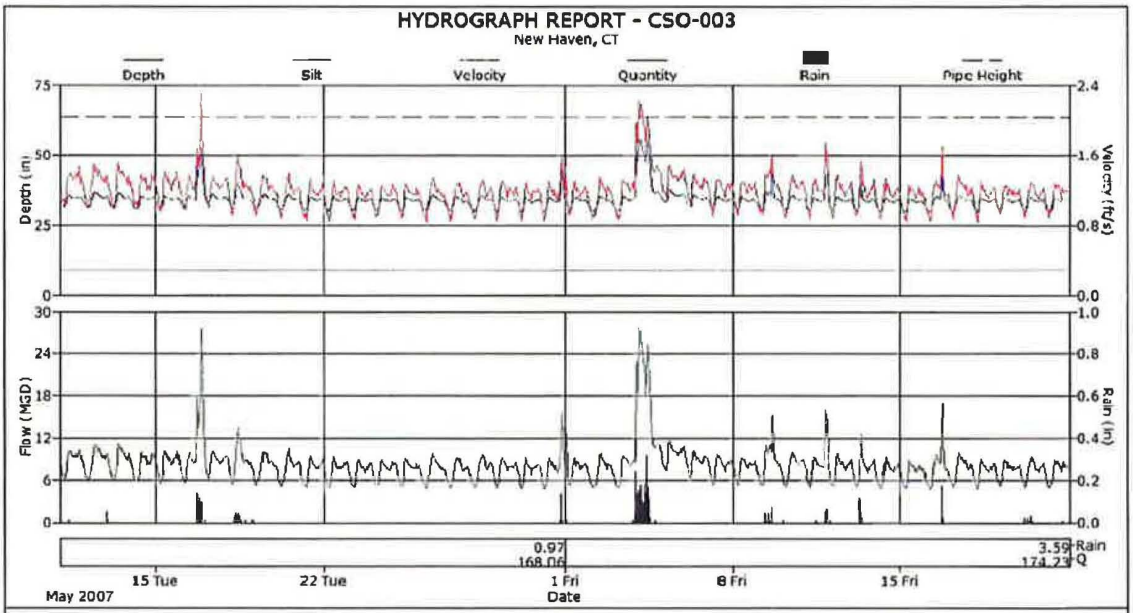
This meter was installed just upstream of the regulating structure at CSO 002 in the Boulevard Interceptor. Depth and velocity data indicate that this location functioned in free-flow conditions for the entire monitoring period. However, a backwater effect was noted during wet weather conditions, most likely a result of a higher level in the wet well at Boulevard Pump Station. Silt was measured at 11.0 inches at this location.



	Depth (in)	Velocity (ft/s)	Calculated Flow (mgd)
Average	28.65	1.25	10.13
Minimum	24.42	0.67	5.08
Maximum	60.61	1.97	31.41
Time of Minimum	6/18/2007 5:30 AM	6/18/2007 5:30 AM	6/18/2007 5:30 AM
Time of Maximum	6/4/2007 10:45 AM	6/4/2007 10:45 AM	6/4/2007 10:45 AM

CSO 003

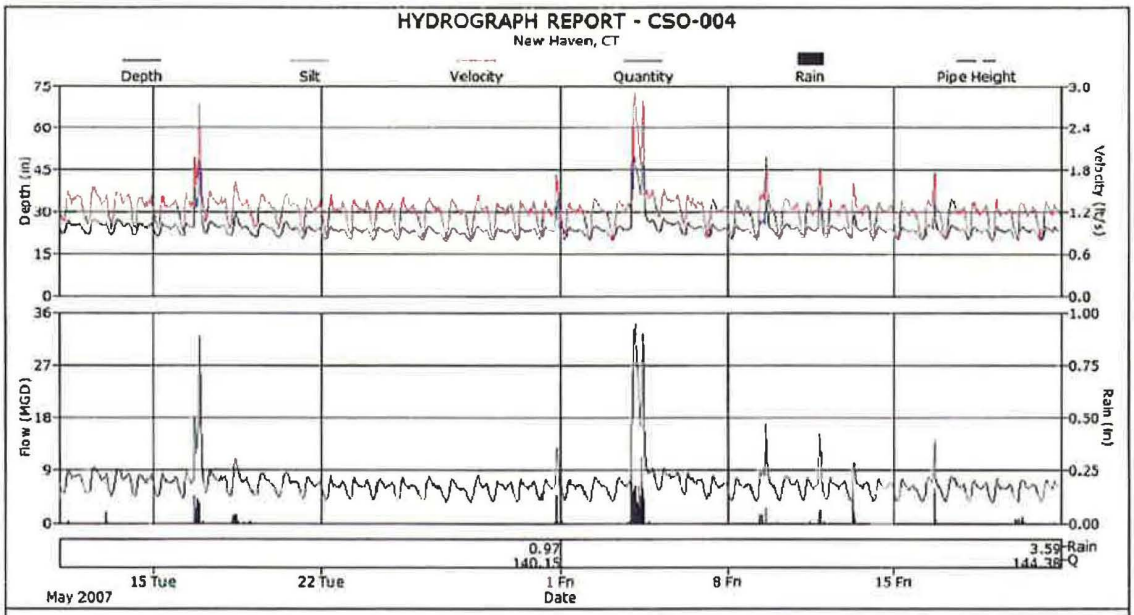
This meter was installed upstream of the regulating structure at CSO 003 in the Boulevard Interceptor. This location functioned in free-flow conditions for the entire monitoring period. Silt was measured at 9.25 inches at this location.



	Depth (in)	Velocity (ft/s)	Calculated Flow (mgd)
Average	33.97	1.20	8.15
Minimum	29.43	0.71	3.87
Maximum	59.61	2.59	33.48
Time of Minimum	6/18/2007 5:15 AM	6/18/2007 5:15 AM	6/18/2007 5:15 AM
Time of Maximum	6/4/2007 10:45 AM	6/4/2007 10:45 AM	6/4/2007 10:45 AM

CSO 004

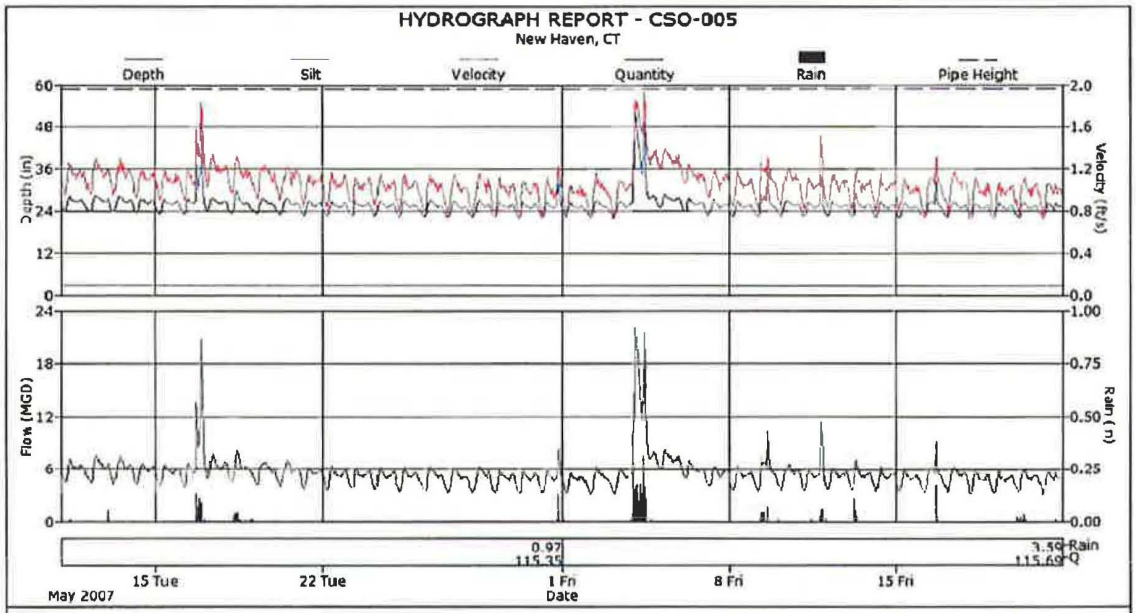
This meter was installed upstream of the regulating structure at CSO 004 in the Boulevard Interceptor, at the intersection of North Frontage Road and E.T. Grasso Boulevard. This location functioned in free-flow conditions for the entire monitoring period. Silt was measured at 2.0 inches at this location.



	Depth (in)	Velocity (ft/s)	Calculated Flow (mgd)
Average	24.00	1.24	6.78
Minimum	19.61	0.71	3.07
Maximum	54.73	3.06	37.07
Time of Minimum	5/27/2007 5:15 AM	5/27/2007 5:15 AM	5/27/2007 5:15 AM
Time of Maximum	5/16/2007 10:30 PM	5/16/2007 10:30 PM	5/16/2007 10:30 PM

CSO 005

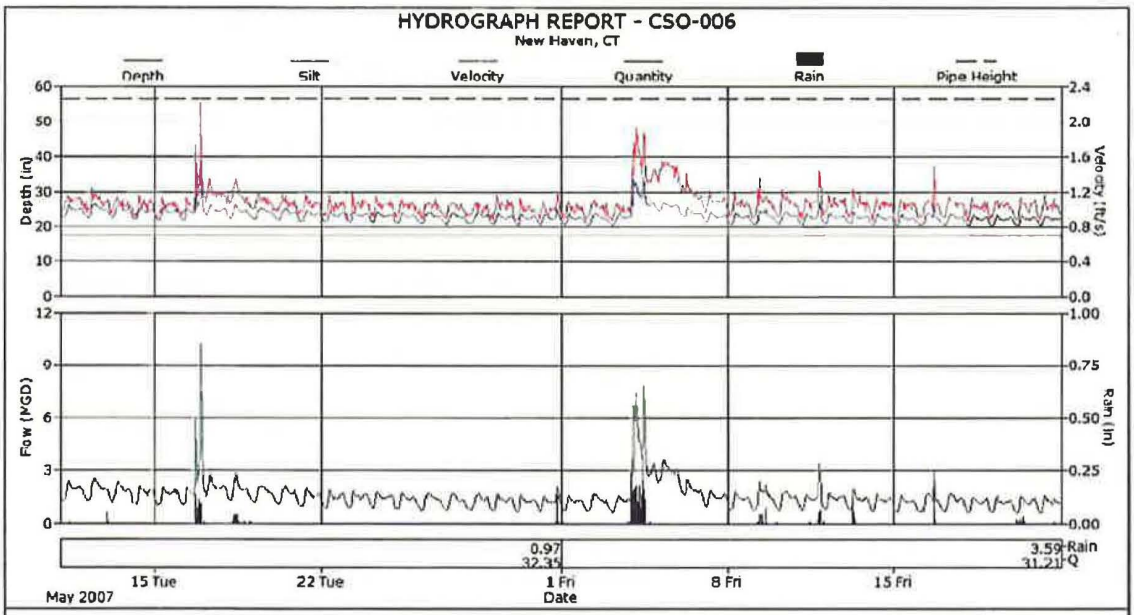
This meter was installed upstream of the regulating structure at CSO 005 in the Boulevard Interceptor, at the intersection of Irving Street and E.T. Grasso Boulevard. This location functioned in free-flow conditions for most of the monitoring period. There were brief periods of surcharge during wet weather events. Silt was measured at 2.5 inches at this location.



	Depth (in)	Velocity (ft/s)	Calculated Flow (mgd)
Average	25.62	1.05	5.50
Minimum	21.62	0.64	2.69
Maximum	59.80	2.02	23.80
Time of Minimum	6/18/2007 4:45 AM	6/18/2007 4:45 AM	6/18/2007 4:45 AM
Time of Maximum	5/16/2007 10:30 PM	5/16/2007 10:30 PM	5/16/2007 10:30 PM

CSO 006

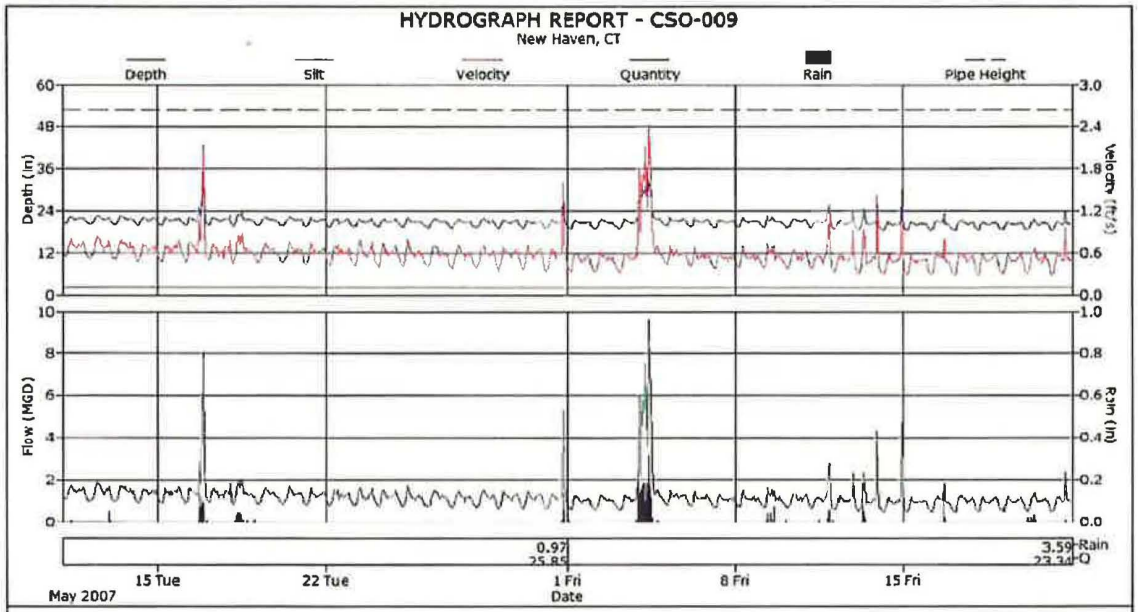
This meter was installed just upstream of the regulating structure at CSO 006 in the Boulevard Interceptor. This location functioned in free-flow conditions for the entire monitoring period. Silt was measured at 17.5 inches at this location.



	Depth (in)	Velocity (ft/s)	Calculated Flow (mgd)
Average	23.01	1.06	1.51
Minimum	20.04	0.77	0.55
Maximum	38.72	2.57	11.17
Time of Minimum	6/21/2007 4:30 AM	6/21/2007 4:30 AM	6/21/2007 4:30 AM
Time of Maximum	5/16/2007 10:30 PM	5/16/2007 10:30 PM	5/16/2007 10:30 PM

CSO 009

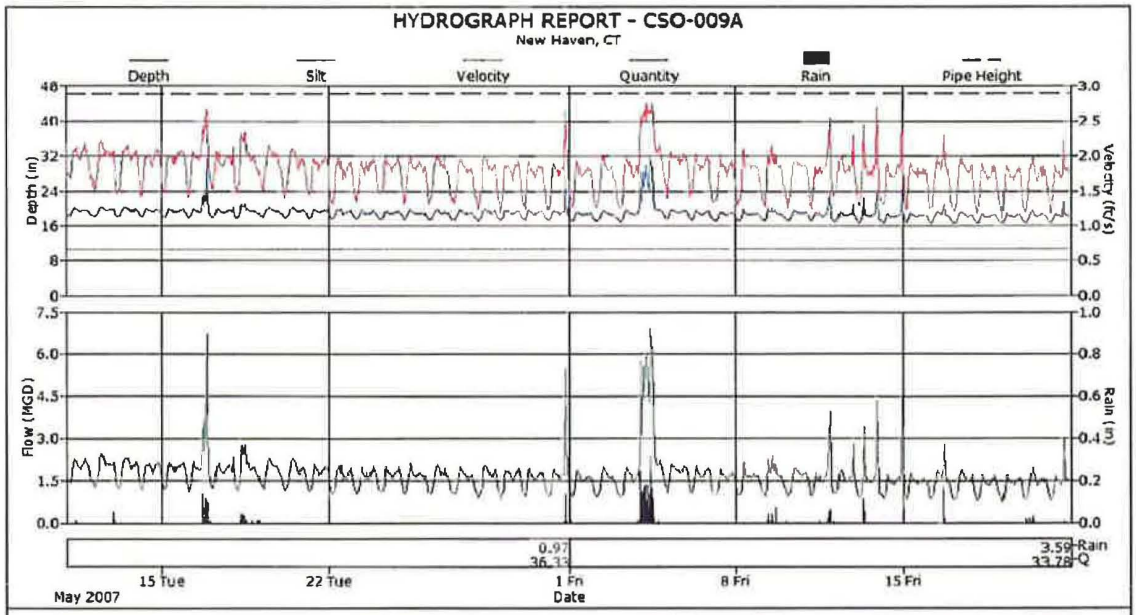
This meter was installed upstream of the CSO 009 regulating structure. This location functioned in free-flow conditions for the entire monitoring period. Silt was measured at 2.0 inches at this location.



	Depth (in)	Velocity (ft/s)	Calculated Flow (mgd)
Average	20.89	0.57	1.17
Minimum	18.47	0.26	0.42
Maximum	36.76	3.70	16.27
Time of Minimum	6/21/2007 3:15 AM	6/21/2007 3:15 AM	6/21/2007 3:15 AM
Time of Maximum	6/4/2007 10:30 AM	6/4/2007 10:30 AM	6/4/2007 10:30 AM

CSO 009A

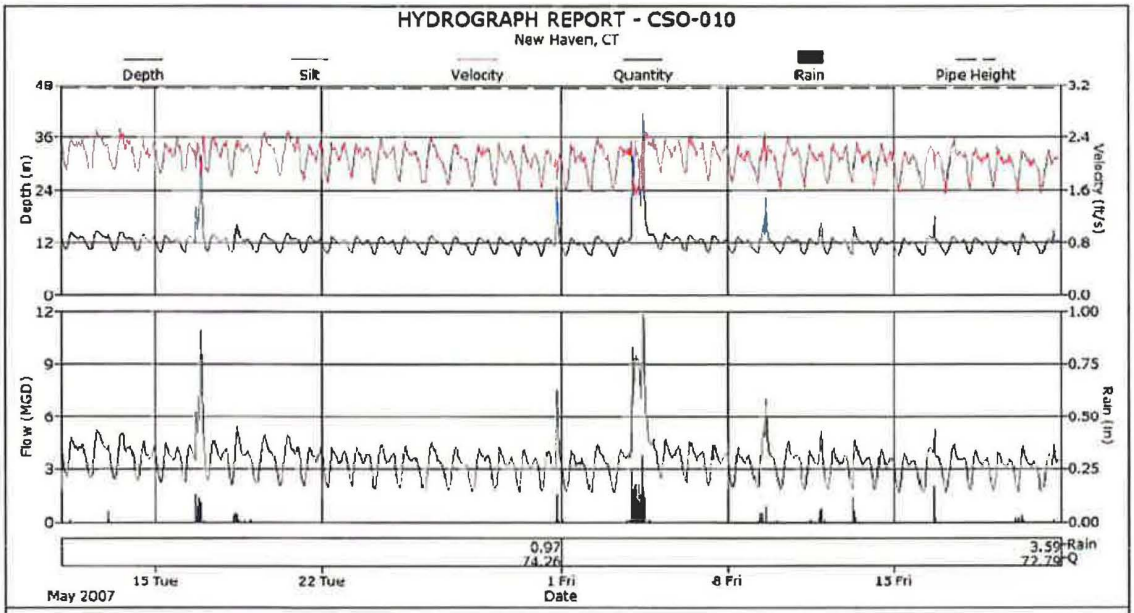
This meter was installed downstream of the CSO 009 regulating structure. This location functioned in free-flow conditions for the entire monitoring period. Silt was measured at 10.5 inches at this location, indicating a significant difference in silt levels from the CSO 009 meter location a few hundred feet upstream.



	Depth (in)	Velocity (ft/s)	Calculated Flow (mgd)
Average	18.69	1.78	1.67
Minimum	16.44	1.01	0.66
Maximum	39.39	2.93	9.96
Time of Minimum	6/21/2007 3:00 AM	6/21/2007 3:00 AM	6/21/2007 3:00 AM
Time of Maximum	5/16/2007 10:30 PM	5/16/2007 10:30 PM	5/16/2007 10:30 PM

CSO 010

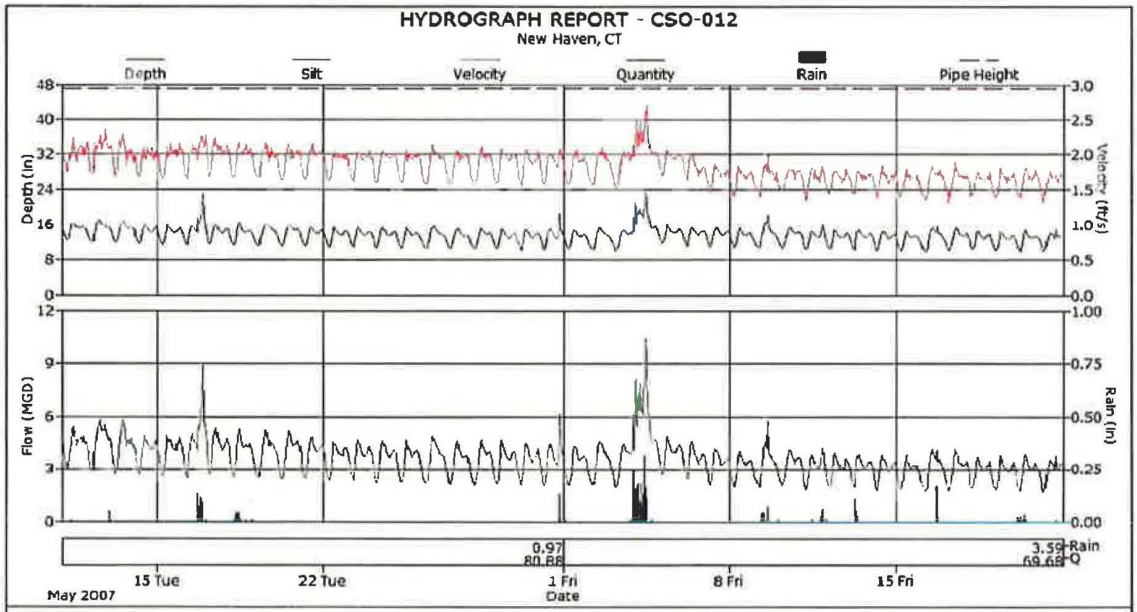
This meter was installed in the regulating structure at CSO 010 between the two outfall pipes. This location functioned in free-flow conditions for most of the monitoring period. When depths were greater than 15 inches, backwater conditions were observed, most likely a result of a higher level in the wet well at East Street Pump Station. No silt was measured at this location.



	Depth (in)	Velocity (ft/s)	Calculated Flow (mgd)
Average	12.24	2.08	3.50
Minimum	8.73	1.37	1.51
Maximum	43.21	2.68	14.43
Time of Minimum	5/30/2007 6:15 AM	5/30/2007 6:15 AM	5/30/2007 6:15 AM
Time of Maximum	6/4/2007 11:30 AM	6/4/2007 11:30 AM	6/4/2007 11:30 AM

CSO 012

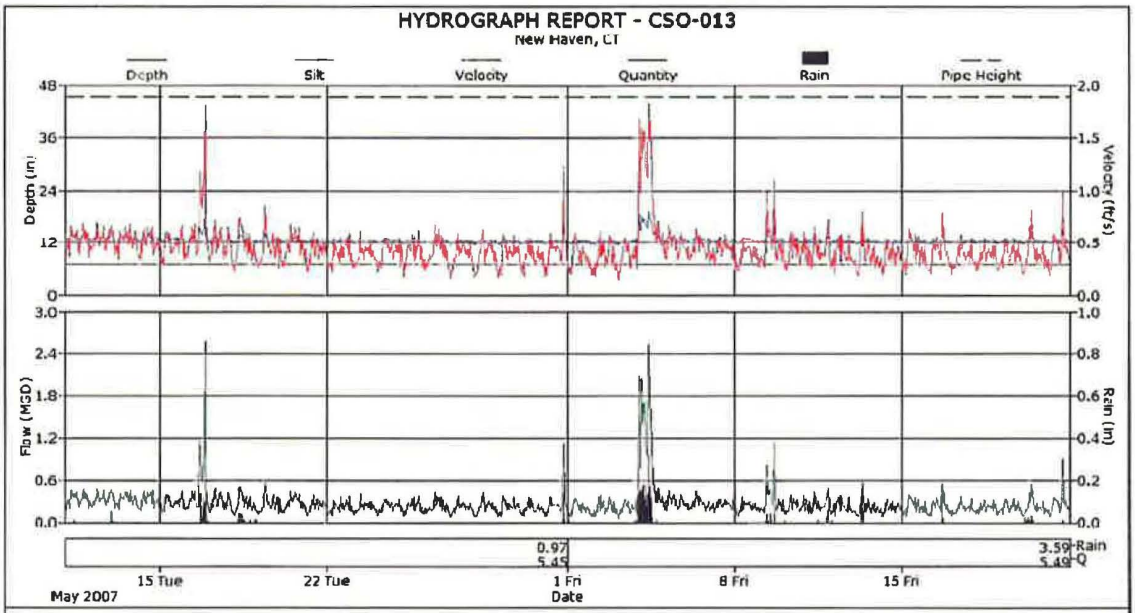
This meter was installed just upstream of the regulating structure at CSO 012. This location functioned in free-flow conditions for the entire monitoring period. No silt was measured at this site. An imbalance with the group of meters upstream of CSO 012 was noted (CSO 013, NH-04, and NH-11). NH-11 contributes the most flow to the CSO 012 location and the imbalance may be explained by an overflow point between NH-11 and CSO 012. ADS recommended further investigation of pipe connectivity in this area to resolve this issue.



	Depth (in)	Velocity (ft/s)	Calculated Flow (mgd)
Average	13.59	1.83	3.59
Minimum	9.89	1.18	1.49
Maximum	25.90	3.15	12.92
Time of Minimum	6/20/2007 6:30 AM	6/20/2007 6:30 AM	6/20/2007 6:30 AM
Time of Maximum	6/4/2007 11:00 AM	6/4/2007 11:00 AM	6/4/2007 11:00 AM

CSO 013

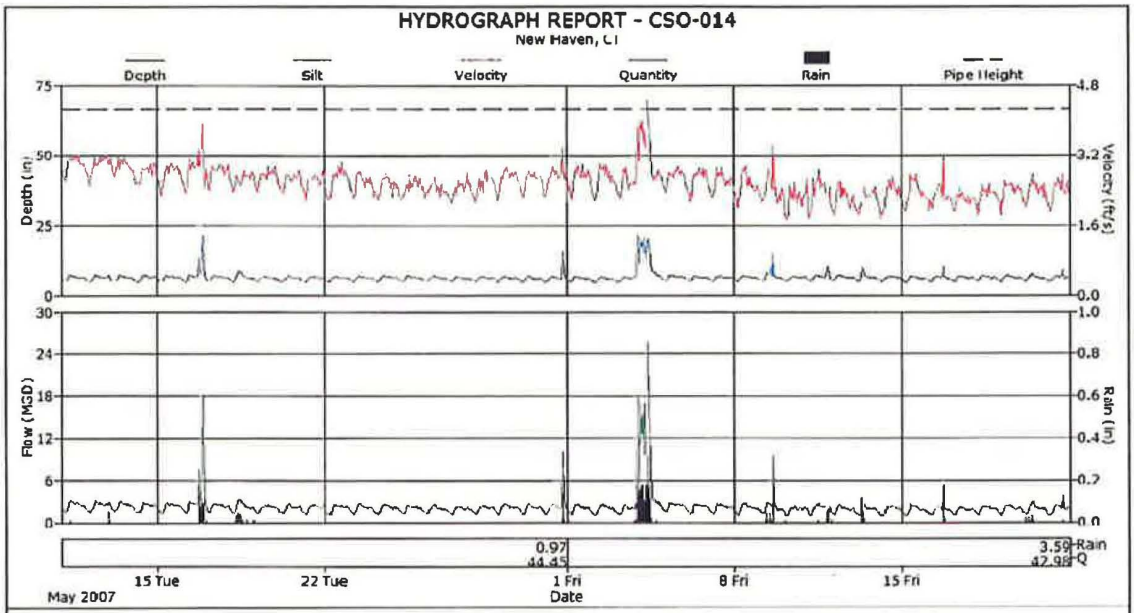
This meter was installed downstream of the regulating structure at CSO 013 at the intersection of East Rock Road and Everit Street. This location functioned in free-flow conditions for the entire monitoring period. Silt was measured at 7.0 inches at this location.



	Depth (in)	Velocity (ft/s)	Calculated Flow (mgd)
Average	12.69	0.44	0.26
Minimum	11.28	0.09	0.035
Maximum	23.90	2.52	4.67
Time of Minimum	6/3/2007 5:00 AM	6/3/2007 5:00 AM	6/3/2007 5:00 AM
Time of Maximum	5/16/2007 10:00 PM	5/16/2007 10:00 PM	5/16/2007 10:00 PM

CSO 014

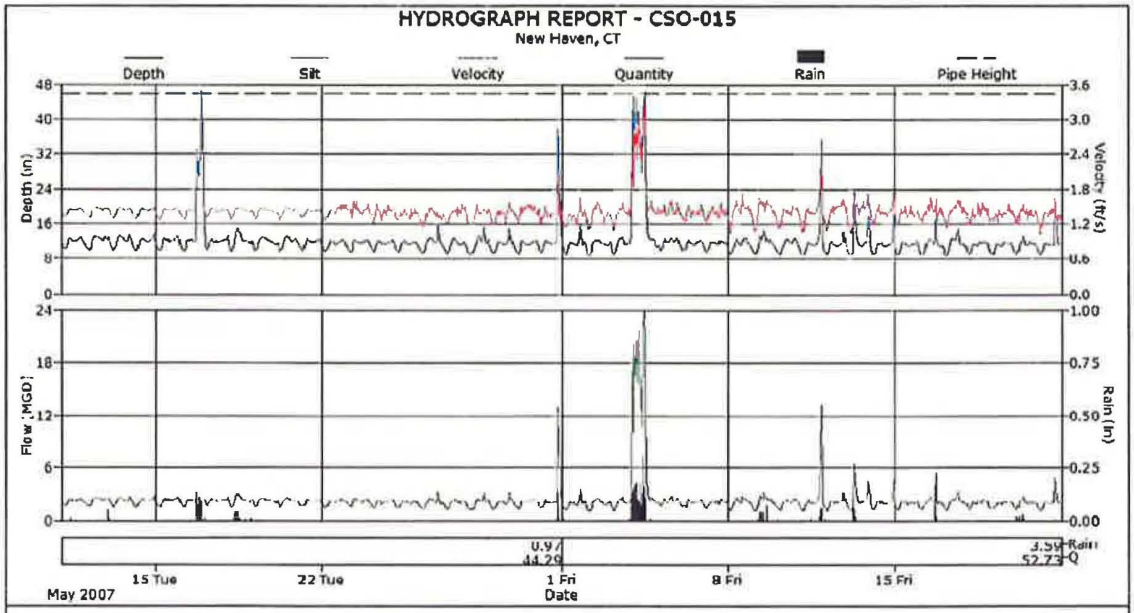
This meter was installed just upstream of the regulating structure at CSO 014. This location functioned in free-flow conditions for the entire monitoring period. No silt was measured at this location.



	Depth (in)	Velocity (ft/s)	Calculated Flow (mgd)
Average	6.41	2.57	2.11
Minimum	4.44	1.62	0.77
Maximum	30.17	4.90	32.66
Time of Minimum	6/3/2007 6:15 AM	6/3/2007 6:15 AM	6/3/2007 6:15 AM
Time of Maximum	6/4/2007 10:45 AM	6/4/2007 10:45 AM	6/4/2007 10:45 AM

CSO 015

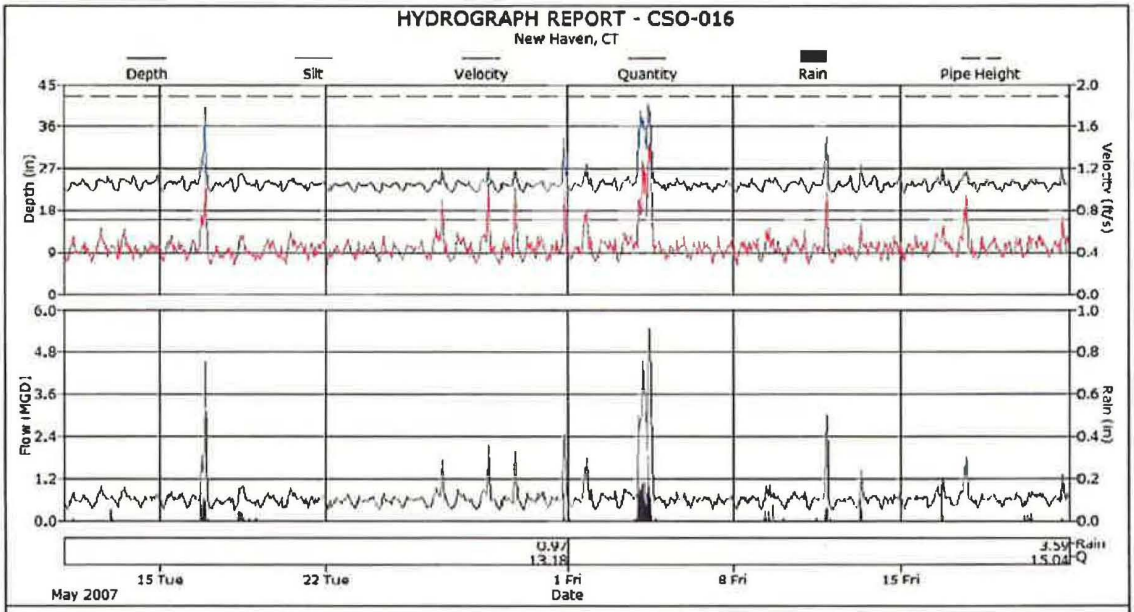
This meter was installed upstream of the regulating structure at CSO 015 just outside the siphon house. This location functioned in free-flow conditions for most of the monitoring period. There were brief periods of surcharge during wet weather events. No silt was measured at this location.



	Depth (in)	Velocity (ft/s)	Calculated Flow (mgd)
Average	12.17	1.41	2.33
Minimum	8.63	0.94	0.96
Maximum	57.60	4.36	32.33
Time of Minimum	6/17/2007 5:45 AM	6/17/2007 5:45 AM	6/17/2007 5:45 AM
Time of Maximum	5/16/2007 10:45 PM	5/16/2007 10:45 PM	5/16/2007 10:45 PM

CSO 016

This meter was installed upstream of the regulating structure at CSO 016 at the intersection of River Street and Poplar Street. This location functioned in free-flow conditions for most of the monitoring period. There were brief periods of surcharge during wet weather events. Silt was measured at 16.0 inches at this location.



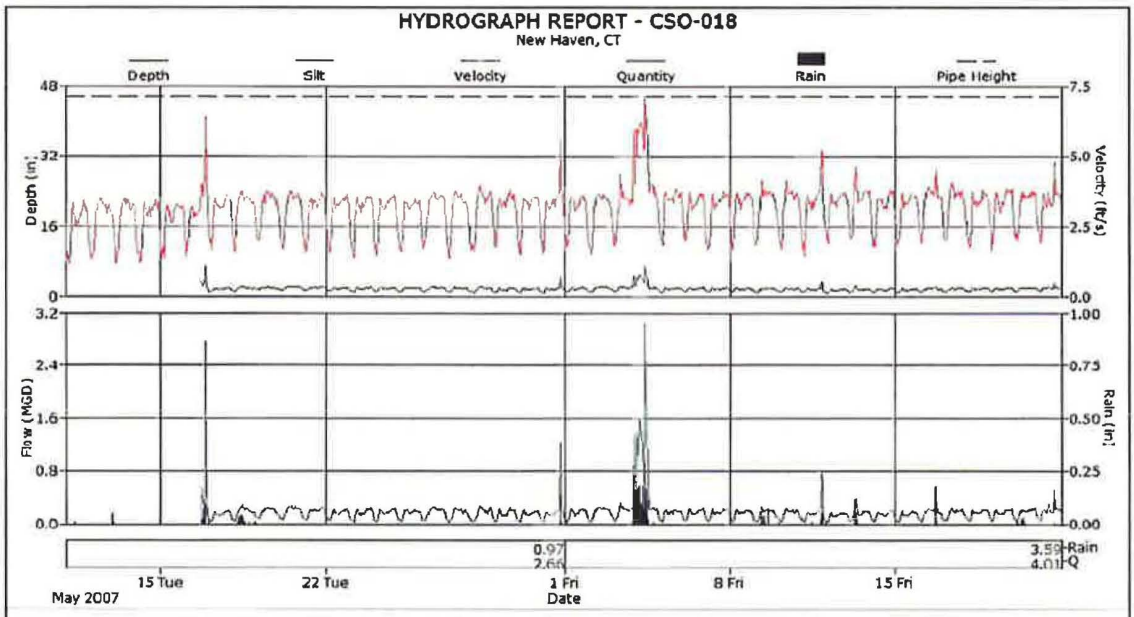
	Depth (In)	Velocity (ft/s)	Calculated Flow (mgd)
Average	23.67	0.45	0.67
Minimum	21.71	0.20	0.23
Maximum	47.34	1.60	6.34
Time of Minimum	6/11/2007 4:30 AM	6/11/2007 4:30 AM	6/11/2007 4:30 AM
Time of Maximum	6/4/2007 10:45 AM	6/4/2007 10:45 AM	6/4/2007 10:45 AM

CSO 017

This meter was installed in the regulating structure at CSO 017. Due to excessive silt and low flow, the velocity meter was unable to provide accurate measurements. The data from this site will not be included in the final hydraulic model verification. This is not anticipated to be detrimental to the verification task, as meter data is available at several sites along the Front Street Interceptor.

CSO 018

This meter was installed in the regulating structure at CSO 018 in Lombard Street. This location functioned in free-flow conditions for the entire monitoring period. No Silt was measured at this location. The percent up-time for this meter was 86.36 percent, which is less than the required up-time of 93 percent.

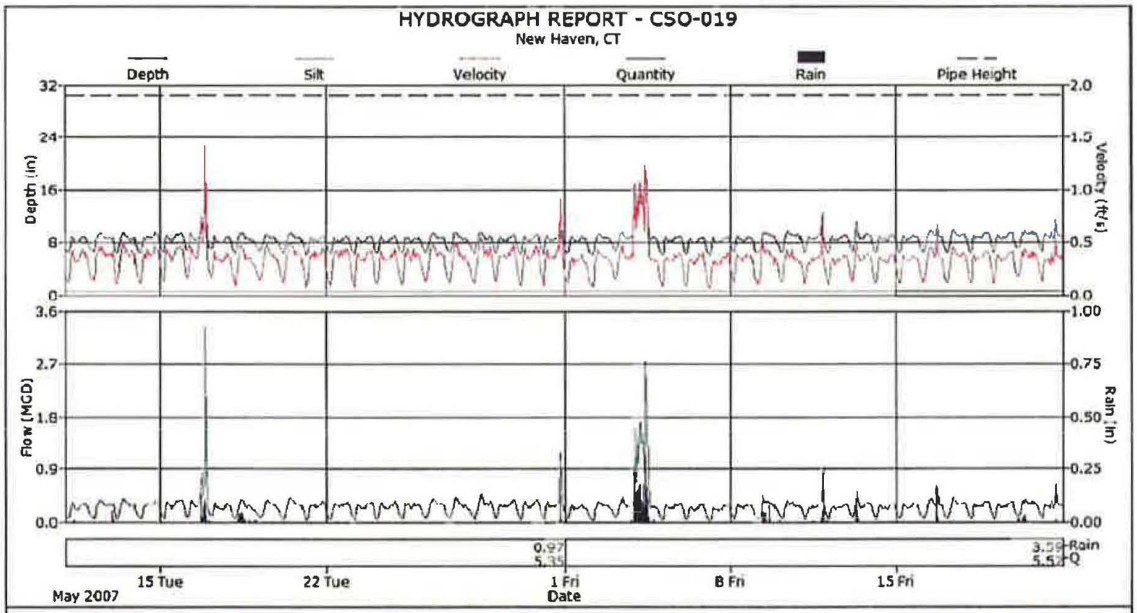


	Depth (in)	Velocity (ft/s)	Calculated Flow (mgd)
Average	1.69	3.14	0.18
Minimum	0.78	0.94	0.018
Maximum	12.52	8.15	7.07
Time of Minimum	5/29/2007 2:30 AM	5/29/2007 2:30 AM	5/29/2007 2:30 AM
Time of Maximum	5/16/2007 10:30 PM	5/16/2007 10:30 PM	5/16/2007 10:30 PM

CSO 019

This meter was installed at the intersection of Front Street and Chatham Street near the site of the old CSO 019 regulating structure. This location functioned in free-flow conditions for the entire monitoring period. Silt was measured at 0.50 inches at this site.

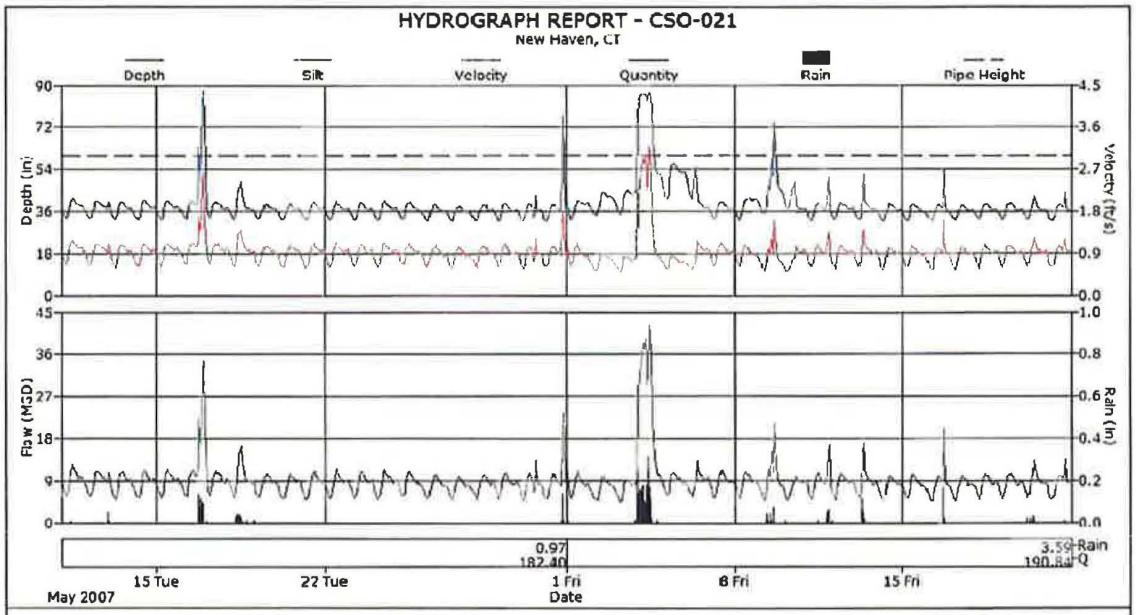
The site report indicates that this meter was installed in a 30-inch diameter circular ductile iron pipe. Record drawings and hydraulic model data indicate that the Front Street Interceptor is a 28-inch x 48-inch box in this location. It is believed that the flow meter was installed in the wrong manhole and possibly measured flows in the stormwater system. Further investigation will be necessary to resolve this issue.



	Depth (in)	Velocity (ft/s)	Calculated Flow (mgd)
Average	8.36	0.33	0.26
Minimum	6.03	0.06	0.026
Maximum	30.40	2.10	6.76
Time of Minimum	5/23/2007 4:45 AM	5/23/2007 4:45 AM	5/23/2007 4:45 AM
Time of Maximum	5/16/2007 10:30 PM	5/16/2007 10:30 PM	5/16/2007 10:30 PM

CSO 021

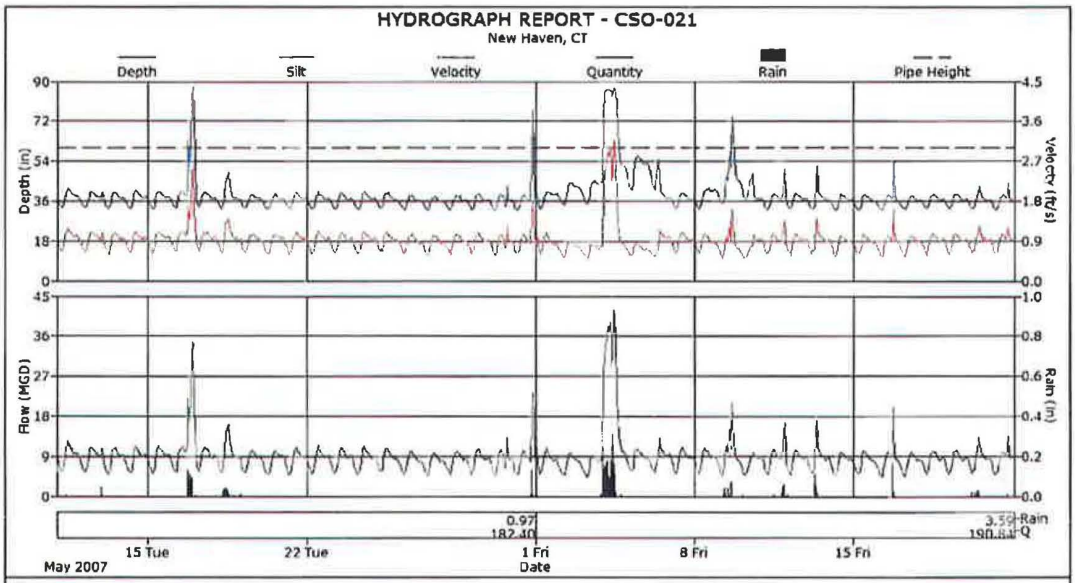
This meter was installed upstream of the East Street Pump Station and regulating structure at CSO 021. This location functioned in free-flow conditions for the entire monitoring period. However, backwater conditions during wet weather should be anticipated given the close proximity of the East Street Pump Station. Further, surcharge was observed upstream at East/Ives and backwater conditions were observed upstream at CSO 010. No silt was measured at this site.



	Depth (in)	Velocity (ft/s)	Calculated Flow (mgd)
Average	38.79	0.91	8.89
Minimum	31.21	0.44	3.82
Maximum	88.27	3.37	44.22
Time of Minimum	5/26/2007 6:00 AM	5/26/2007 6:00 AM	5/26/2007 6:00 AM
Time of Maximum	5/16/2007 11:00 PM	5/16/2007 11:00 PM	5/16/2007 11:00 PM

CSO 021

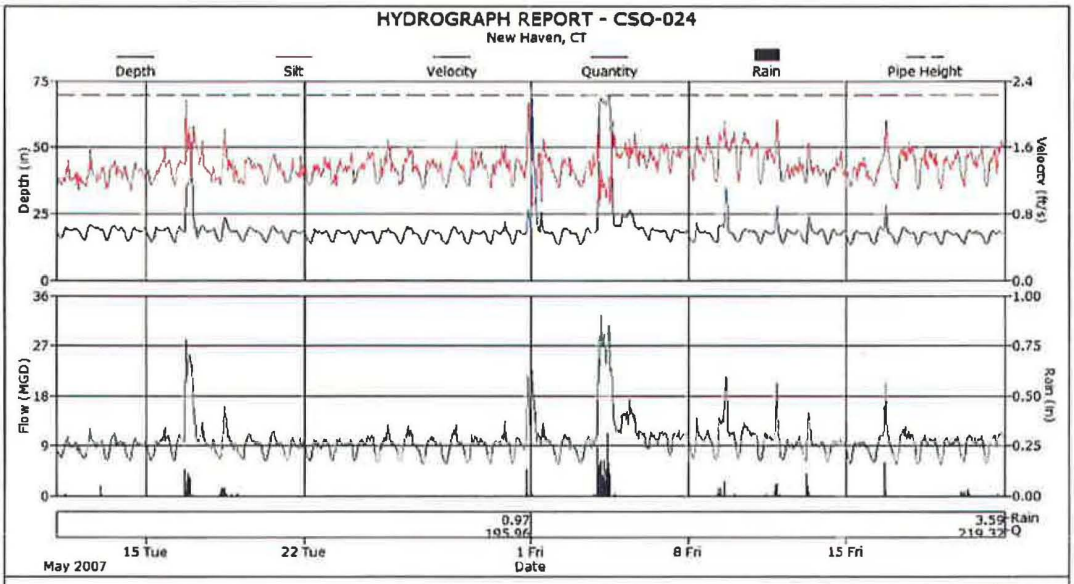
This meter was installed upstream of the East Street Pump Station and regulating structure at CSO 021. This location functioned in free-flow conditions for the entire monitoring period. However, backwater conditions during wet weather should be anticipated given the close proximity of the East Street Pump Station. Further, surcharge was observed upstream at East/Ives and backwater conditions were observed upstream at CSO 010. No silt was measured at this site.



	Depth (in)	Velocity (ft/s)	Calculated Flow (mgd)
Average	38.79	0.91	8.89
Minimum	31.21	0.44	3.82
Maximum	88.27	3.37	44.22
Time of Minimum	5/26/2007 6:00 AM	5/26/2007 6:00 AM	5/26/2007 6:00 AM
Time of Maximum	5/16/2007 11:00 PM	5/16/2007 11:00 PM	5/16/2007 11:00 PM

CSO 024

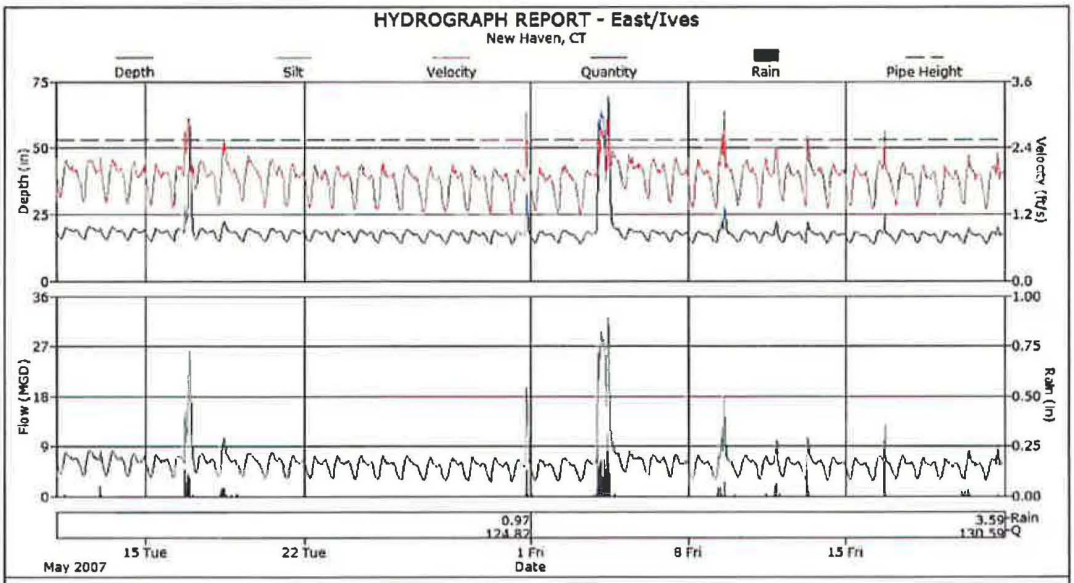
This meter was installed upstream of the Boulevard Pump Station and regulating structure at CSO 024. This location functioned in free-flow conditions for most of the monitoring period. Backwater conditions were observed during wet weather, most likely a result of a higher level in the wet well at Boulevard Pump Station. No silt was measured at this location.



	Depth (In)	Velocity (ft/s)	Calculated Flow (mgd)
Average	18.83	1.38	9.89
Minimum	13.19	0.64	5.36
Maximum	69.75	2.42	39.92
Time of Minimum	6/18/2007 6:00 AM	6/18/2007 6:00 AM	6/18/2007 6:00 AM
Time of Maximum	6/1/2007 2:00 AM	6/1/2007 2:00 AM	6/1/2007 2:00 AM

East/Ives

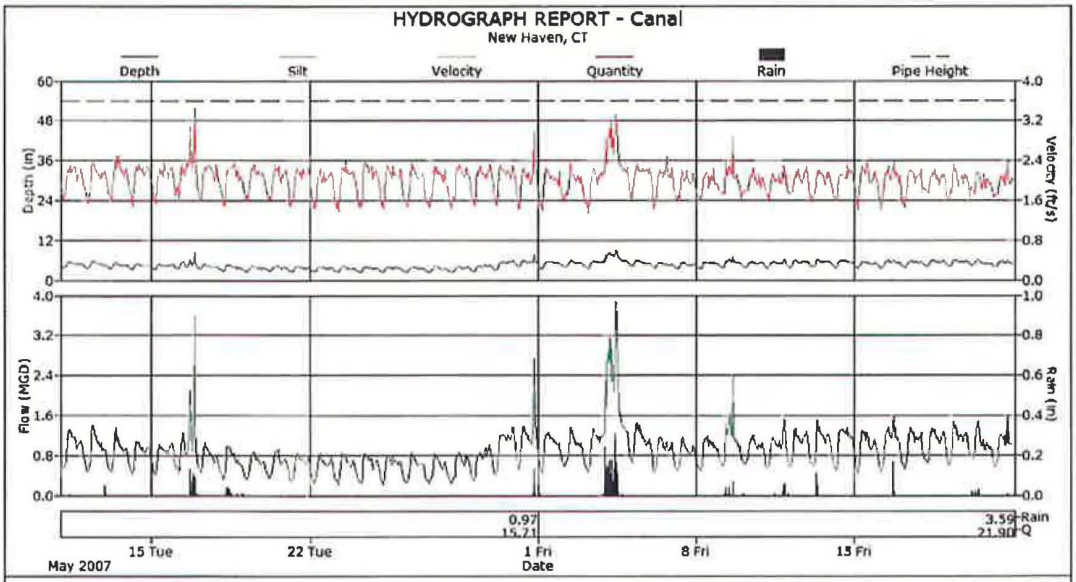
This meter was installed upstream of the overflow at East St./Ives Place in the East Street Interceptor. This location functioned in free-flow conditions for most of the monitoring period. Surcharging was observed during wet weather. No silt was measured at this site.



	Depth (In)	Velocity (ft/s)	Calculated Flow (mgd)
Average	18.17	1.86	6.08
Minimum	13.84	1.11	2.48
Maximum	71.16	3.57	33.56
Time of Minimum	6/3/2007 6:30 AM	6/3/2007 6:30 AM	6/3/2007 6:30 AM
Time of Maximum	6/4/2007 11:00 AM	6/4/2007 11:00 AM	6/4/2007 11:00 AM

Canal

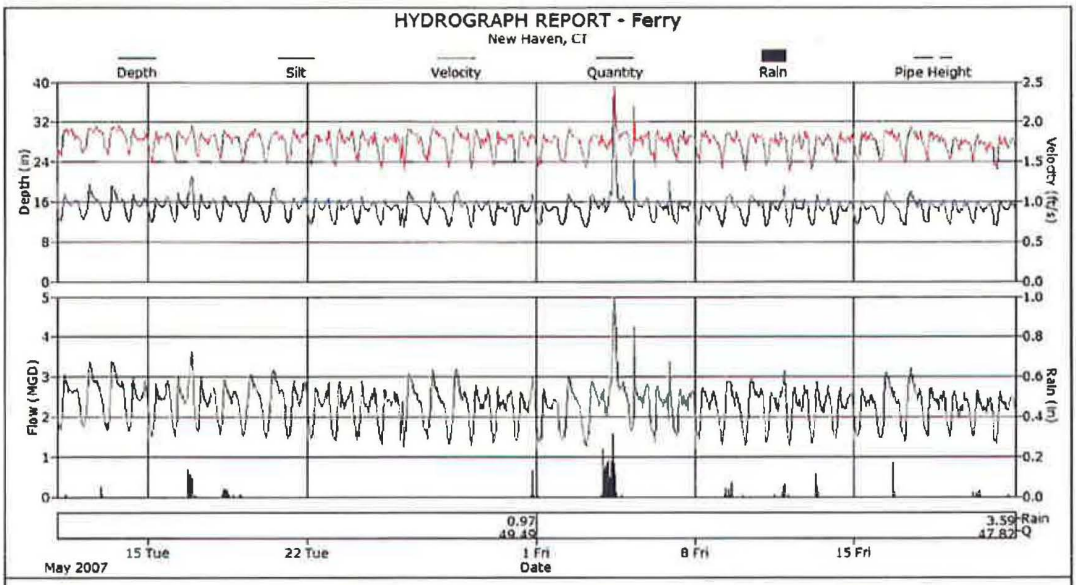
This meter was installed on the East Street Interceptor in Canal Street, south of Munson Street. This location functioned in free-flow conditions for the entire monitoring period. No silt was measured at this location.



	Depth (In)	Velocity (ft/s)	Calculated Flow (mgd)
Average	4.48	2.02	0.90
Minimum	2.18	1.23	0.19
Maximum	9.36	3.77	4.49
Time of Minimum	5/28/2007 4:15 AM	5/28/2007 4:15 AM	5/28/2007 4:15 AM
Time of Maximum	6/4/2007 11:15 AM	6/4/2007 11:15 AM	6/4/2007 11:15 AM

Ferry (Barnes Quinnipiac)

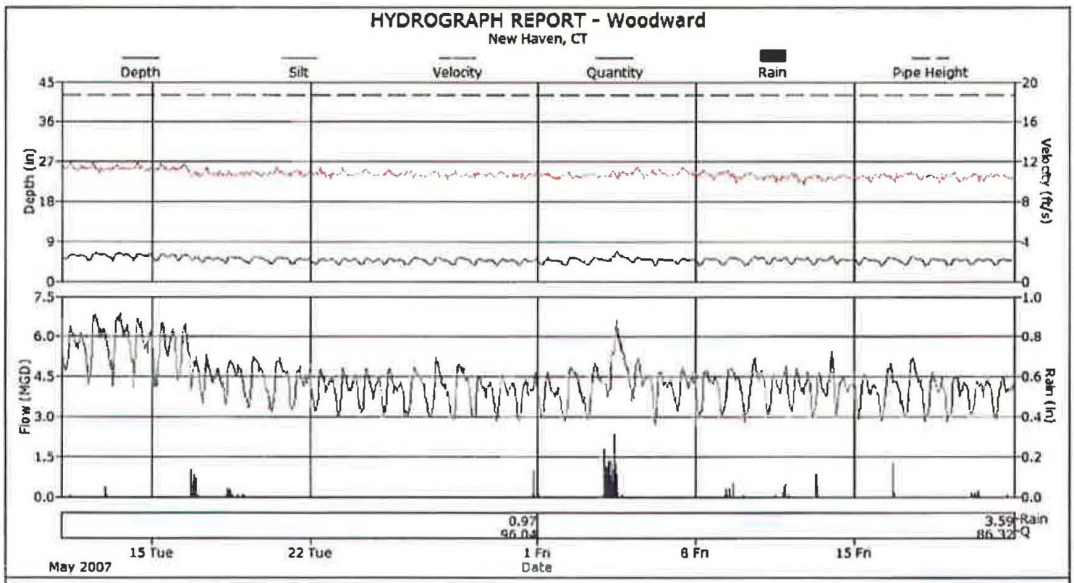
This meter was installed at the intersection of Ferry Street and Fairmont Street to measure flows from the Barnes Pump Station and Quinnipiac Pump Station area of the collection system. This location functioned in free-flow conditions for most of the monitoring period. Surcharging was observed during wet weather. No silt was measured at this site.



	Depth (in)	Velocity (ft/s)	Calculated Flow (mgd)
Average	14.76	1.75	2.32
Minimum	9.91	1.25	1.05
Maximum	38.51	2.56	5.22
Time of Minimum	6/21/2007 3:30 AM	6/21/2007 3:30 AM	6/21/2007 3:30 AM
Time of Maximum	6/4/2007 11:00 AM	6/4/2007 11:00 AM	6/4/2007 11:00 AM

Woodward

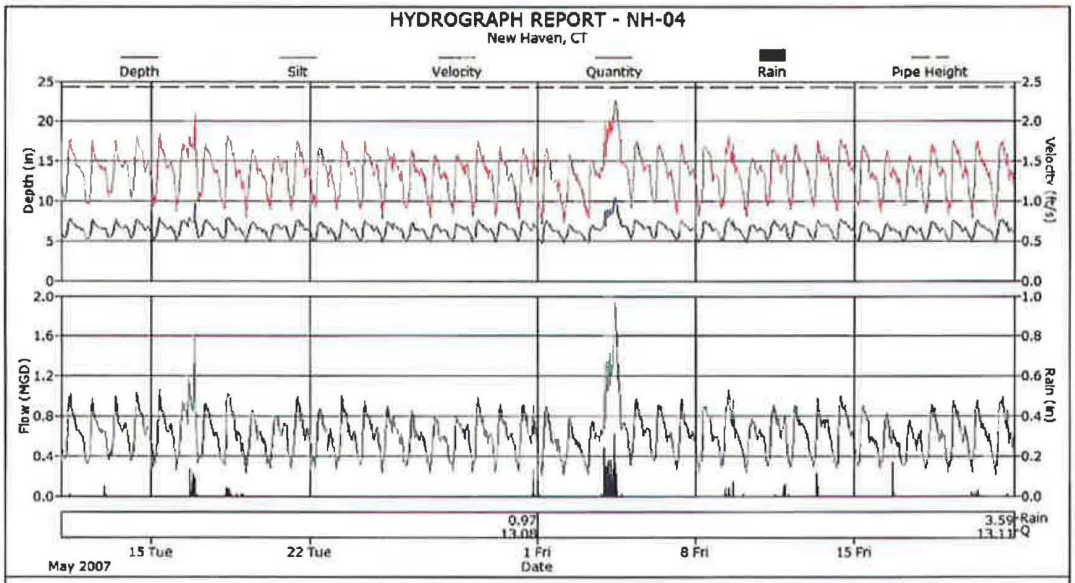
This meter was installed near Woodward Avenue in the Annex Club parking lot to measure flow from the Woodward, Lighthouse, Morris area of the collection system. This location functioned in free-flow conditions for the entire monitoring period. No silt was measured at this site.



	Depth (in)	Velocity (ft/s)	Calculated Flow (mgd)
Average	4.86	10.76	4.34
Minimum	3.35	9.12	2.52
Maximum	6.72	12.42	7.35
Time of Minimum	6/19/2007 2:45 AM	6/19/2007 2:45 AM	6/19/2007 2:45 AM
Time of Maximum	5/13/2007 2:00 PM	5/13/2007 2:00 PM	5/13/2007 2:00 PM

NH-04

This meter was installed at the intersection of Winchester Street and Cave Street, coincident with one of the historical long-term boundary meters. This location functioned in free-flow conditions for the entire monitoring period. No silt was measured at this location.

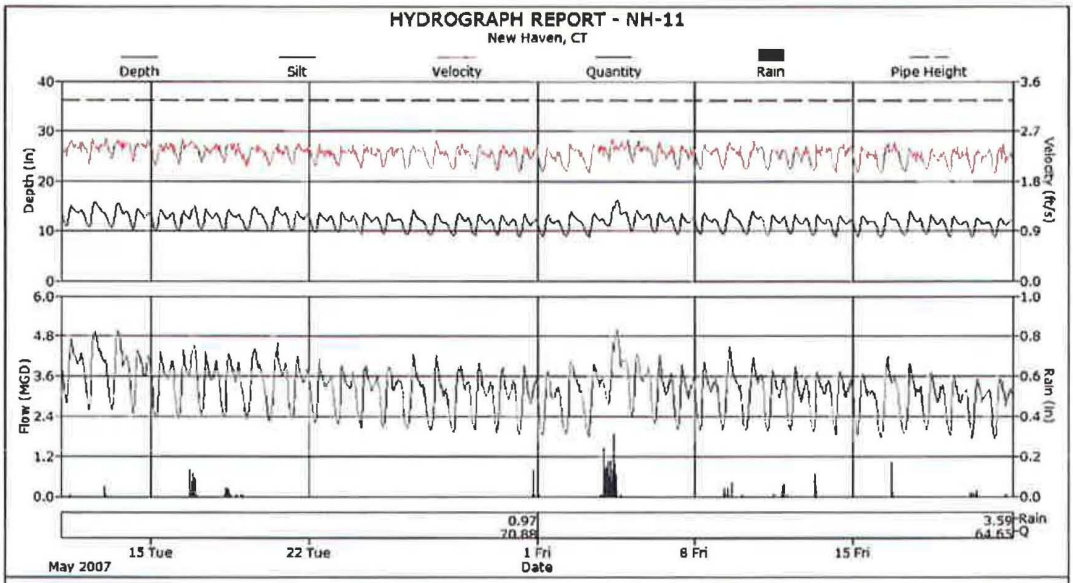


	Depth (in)	Velocity (ft/s)	Calculated Flow (mgd)
Average	6.46	1.36	0.62
Minimum	4.59	0.67	0.18
Maximum	11.74	2.67	2.49
Time of Minimum	6/1/2007 5:15 AM	6/1/2007 5:15 AM	6/1/2007 5:15 AM
Time of Maximum	6/4/2007 11:00 AM	6/4/2007 11:00 AM	6/4/2007 11:00 AM

NH-11

This meter was installed at the intersection of East Rock Road and Livingston Street, coincident with one of the historical long-term boundary meters. This location functioned in free-flow conditions for the entire monitoring period. No silt was measured at this location.

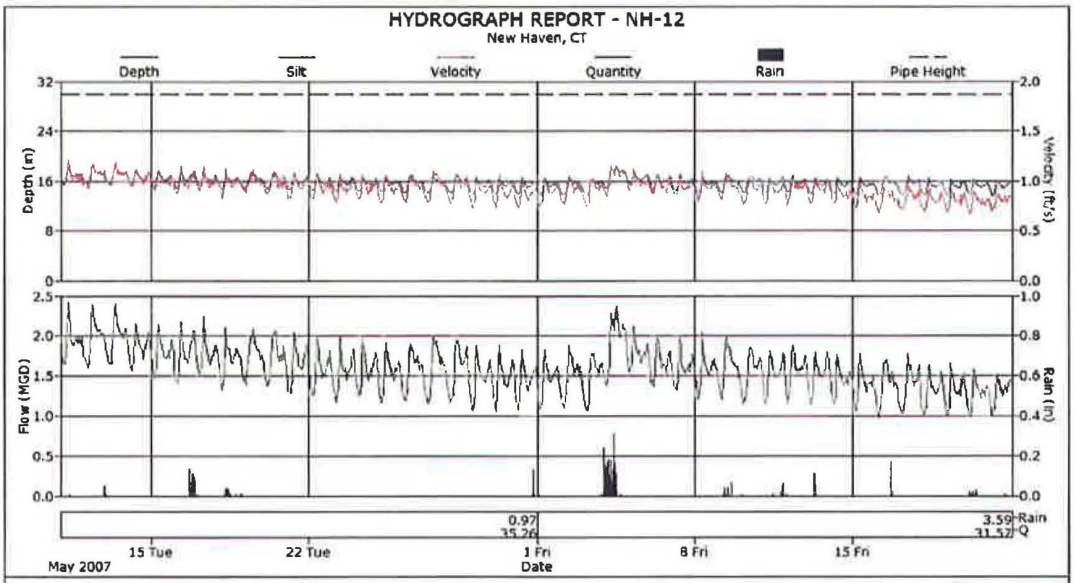
When the depth drops below 10.5 inches at this site, the velocity sensor recorded zero values for velocity, indicating a clear flow. Clear flow is often characteristic of infiltration. In order to provide flow measurements at this site, velocity data was reconstituted using the velocity-depth curve for low flow periods.



	Depth (in)	Velocity (ft/s)	Calculated Flow (mgd)
Average	11.92	2.29	3.23
Minimum	8.73	1.92	1.70
Maximum	16.15	2.69	5.36
Time of Minimum	6/20/2007 5:45 AM	6/20/2007 5:45 AM	6/20/2007 5:45 AM
Time of Maximum	6/4/2007 2:00 PM	6/4/2007 2:00 PM	6/4/2007 2:00 PM

NH-12

This meter was installed in Brookside Avenue between Wilmont Avenue and Wintergreen Avenue, coincident with one of the historical long-term boundary meters. This location functioned in free-flow conditions for the entire monitoring period. No silt was measured at this location.



	Depth (in)	Velocity (ft/s)	Calculated Flow (mgd)
Average	15.71	0.93	1.59
Minimum	13.52	0.64	0.91
Maximum	18.45	1.31	2.68
Time of Minimum	6/21/2007 4:15 AM	6/21/2007 4:15 AM	6/21/2007 4:15 AM
Time of Maximum	5/12/2007 10:30 AM	5/12/2007 10:30 AM	5/12/2007 10:30 AM

Observations

Overall, the flow monitoring data is of acceptable quality. However, there are some inconsistencies that must be taken into consideration during hydraulic model verification. In general, a small number of data issues are to be expected during a flow monitoring study of this magnitude. It is not anticipated that the issues identified below will negatively impact the results of this effort.

- **Data Availability** – All meters met the required 93% up-time with the exception of CSO 018. This meter recorded data during 86.36% of the monitoring period.

- **Mass Balance Discrepancy (CSO 013, NH-04, and NH-11)** – The flow metered at CSO 013, NH-04, and NH-11 combines and flows through the site metered at CSO 012. The sum of the average flows at these three sites is 4.1 mgd, whereas the average flow at CSO 012 is 3.6 mgd. This represents a balancing error of approximately 0.5 mgd, a 12.5 percent difference that may be attributable to time of travel between sites. This difference will be considered during the model verification task. Model calculations will differ slightly from data and it is reasonable to expect all four sites to meet model verification criteria and balance properly in the model.

- **CSO 017** – Due to excessive silt and low flow depths, the velocity sensor was unable to provide accurate measurements at this site. Therefore, flow data could not be calculated for this site. This will not affect the model verification task as there are numerous sites nearby on the Front Street Interceptor.

- **CSO 019** – It is believed that this flow meter was installed in the wrong pipe. Field investigation is necessary to resolve this issue. The flow data from this meter will not be included in the initial model verification.

- **Silt Depths** – Significant silt deposits were measured at a number of meter sites. These depths will be compared to those currently included the hydraulic model and adjusted if necessary.

Letter of Transmittal

ADS ENVIRONMENTAL SERVICES®

July 23, 2007

Mr. William E. McMillin, JR., P.E.

CH2MHILL

99 Cherry Hill Road, Suite 200

Parsippany, NJ 07054-1102

SUBJECT: New Haven, CT Temporary Flow Monitoring Study

Dear Mr. McMillin,

ADS is pleased to submit the Final Report for the New Haven, CT Temporary Flow Monitoring Study conducted for CH2MHILL.

Presented in this report are hydorgraphs, scattergraphs and longtables of the data collected and analyzed from Friday, May 11, 2007 to Thursday, June 21, 2007 . Also included are Excel files containing Depth, Quantity, and Velocity entities for each flow monitoring location and rain gauges in 15-minute format. Please note the minimum and maximum rates recorded on the daily tabular data are absolute versus average fifteen minute data.

In addition, we would be happy to further explain any details about the report that may seem unclear. Should you have any questions or comments, please contact the Project Manager, George Elaro at (845) 268-1201 or me at ext. 222.

Thank you for choosing ADS products and services to meet your flow monitoring needs.

Sincerely,
ADS ENVIRONMENTAL SERVICES

Rodianne Cadet
Data Manager

4940 Research Drive • Huntsville, AL 35805 • phone: 256-430-3366 • Fax: 256-430-6633

Methodology

Introduction

Background

CH2MHILL entered into agreement with ADS Environmental Services to conduct flow monitoring at twenty-five (25) metering locations with three (3) rain gauges located in New Haven, CT. The study was for a monitoring period beginning on Friday, May 11, 2007 and ending on Thursday, June 21, 2007 . The objective of this study was to measure depth, velocity, and quantify flows.

Project Scope

The scope of this study involved using a temporary flow monitor to quantify wastewater flow at the designated locations. Specifically, the study included the following key components:

- Investigate the proposed flow-monitoring site for adequate hydraulic conditions.
- Flow monitor installation.
- Flow monitor confirmations and data collections.
- Flow data analysis.

Equipment and Methodology

Flow Quantification Methods

There are two main equations used to measure open channel flow: the Continuity Equation and the Manning Equation. The **Continuity Equation**, which is considered the most accurate, can be used if both depth of flow and velocity are available. In cases where velocity measurements are not available or not practical to obtain, the **Manning Equation** can be used to estimate velocity from the depth data based on certain physical characteristics of the pipe (i.e. the slope and roughness of the pipe being measured). However, the Manning equation assumes uniform, steady flow hydraulic conditions with non-varying roughness, which are typically invalid assumptions in most sanitary sewers. Both the Continuity and Manning Equation was used for this study.

Flow Monitoring Equipment

The monitor selected for this project was the ADS Model 3500-flow monitor. This flow monitor is anarea velocity flow monitor that uses both the Continuity and Manning's equations to measure flow.

The ADS Model 3500-flow monitor consists of data acquisition sensors and a battery-powered microcomputer. The microcomputer includes a processor unit, data storage, and an on-board clock to control and synchronize the sensor recordings. The monitor was programmed to acquire and store depth of flow and velocity readings at 15-minute intervals.

Three types of data acquisition sensors are available for the Model 3500 flow monitor. The primary depth measurement device is the ADS quad-redundant ultrasonic level sensor. This sensor uses four independent ultrasonic transceivers in pairs to measure the distance from the face of the transceiver housing to the water surface (air range) with up to four transceiver pairs, of the available ones, active at one time. The elapsed time between transmitting and receiving the ultrasonic waves is used to calculate the air range between the sensor and flow surface based on the speed of sound in air. Sensors in the transceiver housing measure temperature, which is used to compensate the ultrasonic signal travel time. The speed of sound will vary with temperature. Since the ultrasonic level sensor is mounted out of the flow, it creates no disturbance to normal flow patterns and does not affect site hydraulics.

Redundant flow depth data can be provided by a pressure depth sensor, and is independent from the ultrasonic level sensor. This sensor uses a piezo-resistive crystal to determine the difference between

hydrostatic and atmospheric pressure. The pressure sensor is temperature compensated and vented to the atmosphere through a desiccant filled breather tube. Pressure depth sensors are typically used in large size channels and applications where surcharging is anticipated. Its streamlined shape minimizes flow distortion.

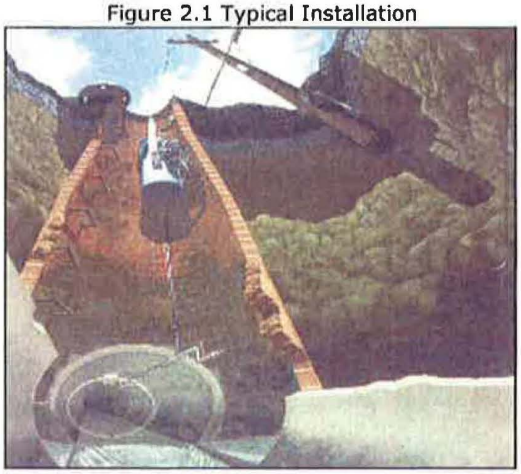
Velocity is measured using the ADS V-3 digital Doppler velocity sensor. This sensor measures velocity in the cross-sectional area of flow. An ultrasonic carrier is transmitted upstream into the flow, and is reflected by suspended particles, air bubbles, or organic matter with a frequency shift proportional to the velocity of the reflecting objects. The reflected signal is received by the sensor and processed using digital spectrum analysis to determine the peak flow velocity. Collected peak velocity information is filtered and processed using field confirmation information and proprietary software to determine the average velocity, which is used to calculate flow quantities. The sensor's small profile, measuring 1.5 inches by 1.15 inches by 0.50 inches thick, minimizes the affects on flow patterns and site hydraulics.

Installation

Installation of flow monitoring equipment typically proceeds in four steps. First, the site is investigated for safety and to determine physical and hydraulic suitability for the flow monitoring equipment. Second, the equipment is physically installed at the selected location. Third, the monitor is tested to assure proper operation of the velocity and depth of flow sensors and verify that the monitor clock is operational and synchronized to the master computer clock. Fourth, the depth and velocity sensors are confirmed and line confirmations are performed. A typical flow monitor installation is shown in Figure 2.1.

The installations depicted in Figures 2.1 are typical for circular or oval pipes up to approximately 104-inches in diameter or height. In installations into pipes 42-inches or less in diameter, depth and velocity sensors are mounted on an expandable stainless steel ring and installed one to two pipe diameters upstream of the pipe/manhole connection in the incoming sewer pipe. This reduces the affects of turbulence and backwater caused by the connection. In pipes larger than 42 inches in diameter, a special installation is made using two sections of the ring installed one to two feet upstream of the pipe/manhole connection; one bolted to the crown of the pipe for the depth sensor, and the other bolted to the bottom of the pipe (bolts are usually placed just above the water line) to hold the velocity sensor.

Figure 2.1 Typical Installation



Large Pipe (> 42" Diameter) **Small Pipe (8" to 42" Diameter)**

Data Collection, Confirmation, and Quality Assurance

During the monitoring period, field crews visit each monitoring location to retrieve data, verify proper monitor operation, and document field conditions. The following quality assurance steps are taken to assure the integrity of the data collected:

- **Measure Power Supply:** The monitor is powered by a dry cell battery pack. Power levels are recorded and battery packs replaced, if necessary. A separate battery provides back-up power to memory, which allows the primary battery to be replaced without the loss of data.
- **Perform Pipe Line Confirmations and Confirm Depth and Velocity:** Once equipment and sensor installation is accomplished, a member of the field crew descends into the manhole to perform a field measurement of flow rate, depth and velocity to confirm they are in agreement with the monitor. Since the ADS V-3 velocity sensor measures peak velocity in the wetted cross-sectional area of flow, velocity profiles are also taken to develop a relationship between peak and average velocity in lines that meet the hydraulic criteria.
- **Measure Silt Level:** During site confirmation, a member of the field crew descends into the manhole and measures and records the depth of silt at the bottom of the pipe. This data is used to compute the true area of flow.
- **Confirm Monitor Synchronization:** The field crew checks the flow monitor's clock for accuracy.
- **Upload and Review Data:** Data collected by the monitor is uploaded and reviewed for comparison with previous data. All readings are checked for consistency and screened for deviations in the flow patterns, which indicate system anomalies or equipment failure.

Data Analysis and Presentation

Data Analysis

A flow monitor is typically programmed to collect data at either 15-minute or 5-minute intervals throughout the monitoring period. The monitor stores raw data consisting of (1) the air range (distance from sensor to top of flow) for each active ultrasonic depth sensor pair and (2) the peak velocity. If the monitor is equipped with a pressure sensor, then a depth reading from this sensor may also be stored. When the field personnel collects the data, the air range is converted to depth data based on the pipe height and physical offset (distance from the top of the pipe to the surface of the ultrasonic sensor). The data is imported into ADS's proprietary software and is examined by a data analyst to verify its integrity. The data analyst also reviews the daily field reports and site visit records to identify conditions that would affect the collected data.

Velocity profiles and the line confirmation data developed by the field personnel are reviewed by the data analyst to identify inconsistencies and verify data integrity. Velocity profiles are reviewed and an average to peak velocity ratio is calculated for the site. This ratio is used in converting the peak velocity measured by the sensor to the average velocity used in the Continuity equation. The data analyst selects which

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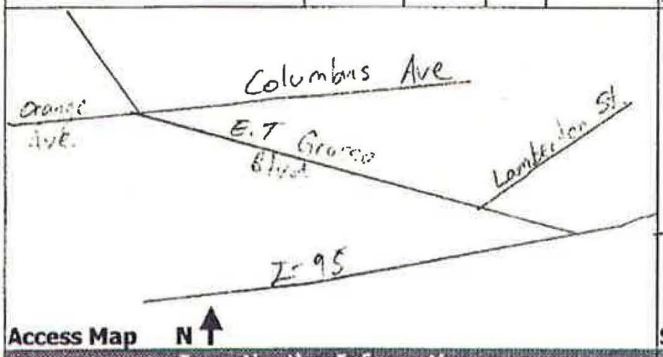
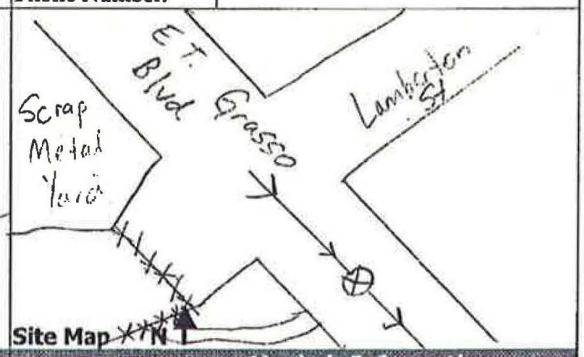
ADS Site Report — Quality Form

Project Name: New Haven TM				City/State: New Haven, CT		FM Initials: GF
Site Name: CSO-002	Monitor Series: 3500			Monitor S/N:	4650	
Address / Location: Under E.T. Grasso Blvd. at Metal Scrap Yard.				Manhole #:		
				Map Page #:		
Access: Drive	Type of System:	Sanitary ☐	Storm ☐	Combined ☒	Pipe Height:	62.00
					Pipe Width:	84.00
					Phone Number:	



Access Map N



Site Map N

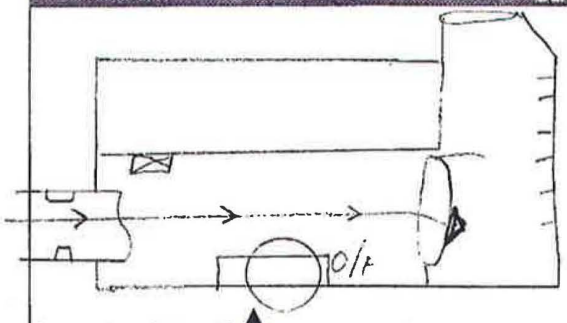
Investigation Information:

Date/ Time of Investigation:	4/10/07
Site Hydraulics:	Deep, Smooth Slow Flow
Upstream Input: (L/S, P/S)	NF
Upstream Manhole:	DNI
Downstream Manhole:	DNI
Depth of Flow (Wet Dof):	38.38 +/-
Range (Air Dof):	4.0 +/-
Peak Velocity:	2.02 fps
Silt:	9.00 Inches

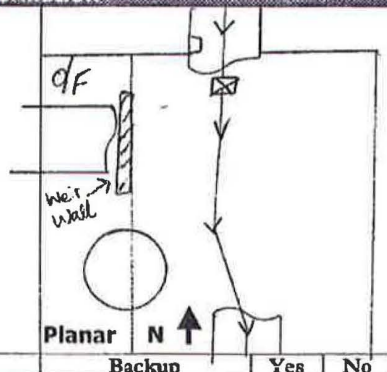
Manhole Information:

Manhole Depth:	16 Feet				
Manhole Material / Condition:	Concrete / Fair				
Pipe Material / Condition:	Concrete / Fair				
Mini System Character:	Residential ☐	Commercial ☒	Industrial ☒	Other	
Telephone Information:	—				
Access Pole #:	—				
Distance From Manhole:	— Feet				
Road Cut Length:	— Feet				
Trench Length:	— Feet				

Other Information



Cross Section N



Planar N

Installation Information		Backup	Yes	No	?	Distance
Installation Type:	Special	Trunk	☐	☒		
Sensors/Devices:	Velocity, Depth, Pressure	Lift/Pump Station	☐	☒		
Surcharge Height:	6 Feet	WWTP	☐	☒		
Rain Gauge Zone:	RG-1	Other	☐	☒		

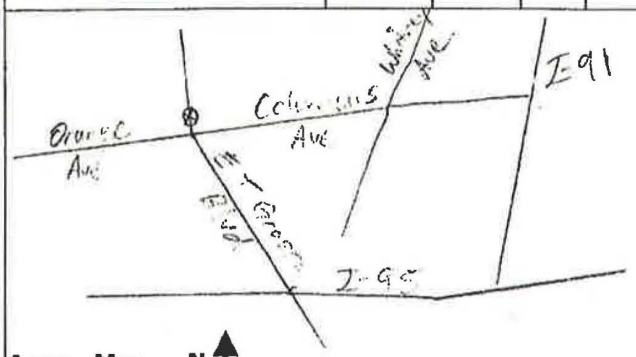
Additional Site Information/Comments:

GNH0016-095

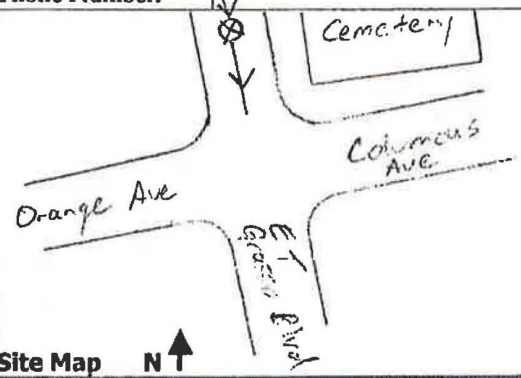
ADS ENVIRONMENTAL SERVICES

ADS Site Report — Quality Form

Project Name: New Haven - FM				City/State: New Haven CT		FM Initials: GE
Site Name: CSO-003	Monitor Series: 4000			Monitor S/N:	1232	
Address / Location: In Middle of E T Conte Blvd. North of Orange Ave				Manhole #:		
				Map Page #:		
Access: Drive.	Type of System:	Sanitary ☐	Storm ☐	Combined ☒	Pipe Height:	63.63"
					Pipe Width:	66.50'
					Phone Number:	



Access Map N



Site Map N

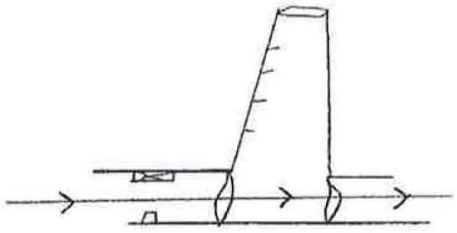
Investigation Information:

Date/ Time of Investigation:	4/11/07		
Site Hydraulics:	Deep, smooth flow.		
Upstream Input: (L/S, P/S)	NA		
Upstream Manhole:	Did not Investigate		
Downstream Manhole:	Not accessible		
Depth of Flow (Wet Dof):	1' 35.50 +/-		
Range (Air Dof):	27.50 +/-		
Peak Velocity:	1.10 fps		
Silt:	0 in. Inches		

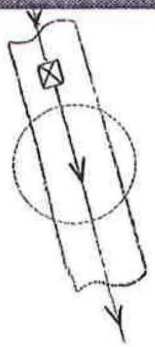
Manhole Information:

Manhole Depth:	7.50 Feet				
Manhole Material / Condition:	Brick / Fair				
Pipe Material / Condition:	Brick / Fair				
Mini System Character:	Residential ☒	Commercial ☒	Industrial ☐	Other	
Telephone Information:	---				
Access Pole #:	---				
Distance From Manhole:	--- Feet				
Road Cut Length:	--- Feet				
Trench Length:	--- Feet				

Other Information



Cross Section N



Planar N

Installation Information		Backup	Yes	No	?	Distance
Installation Type:	Special Insert	Trunk	☐	☒		
Sensors/Devices:	Ultra. Vel., Press.	Lift/Pump Station	☐	☒		
Surcharge Height:	6. Feet	WWTP	☐	☒		
Rain Gauge Zone:	RG-1	Other	☐	☒		

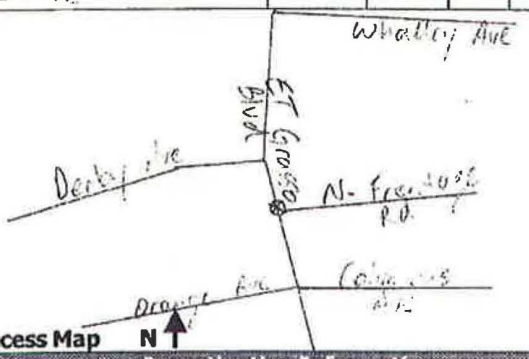
Additional Site Information / Comments:

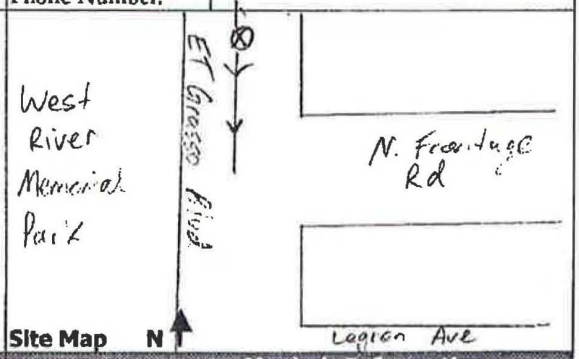
GNH0016-096

ADS ENVIRONMENTAL SERVICES

ADS Site Report — Quality Form

Project Name: New Haven TFM				**City/State:** New Haven CT		**FM Initials:** GE	
Site Name: CSO-004	**Monitor Series:** 4000			**Monitor S/N:**	1238		
Address / Location: In traffic Island on ET Grossa Blvd North of N. Frontage Rd.				**Manhole #:**			
				Map Page #:			
Access: Drive	**Type of System:**	**Sanitary** ☐	**Storm** ☐	**Combined** ☒	**Pipe Height:**	60-28"	
					Pipe Width:	63-72"	
					Phone Number:		





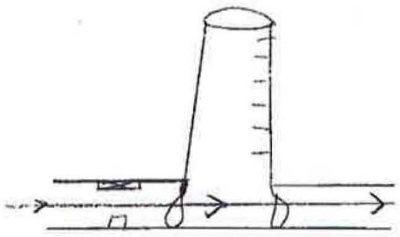
Investigation Information:

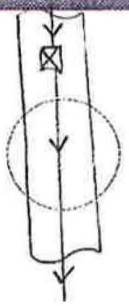
Date/ Time of Investigation:	4/11/07
Site Hydraulics:	Smooth, deep flow.
Upstream Input: (L/S, P/S)	NA
Upstream Manhole:	DN2
Downstream Manhole:	DN3
Depth of Flow (Wet Dof):	27.00 +/-
Range (Air Dof):	32.00 +/-
Peak Velocity:	1.80 fps
Silt:	2.00 Inches

Manhole Information:

Manhole Depth:	9 Feet				
Manhole Material / Condition:	Brick / Fair				
Pipe Material / Condition:	Brick / Fair				
Mini System Character:	**Residential** ☒	**Commercial** ☐	**Industrial** ☐	**Other**	
Telephone Information:	—				
Access Pole #:	—				
Distance From Manhole:	— Feet				
Road Cut Length:	— Feet				
Trench Length:	— Feet				

Other Information





Installation Information	
Installation Type:	Sensors on Pipes
Sensors/Devices:	Ultra, Vel + Press
Surcharge Height:	6 Feet
Rain Gauge Zone:	RG-2

Backup	Yes	No	?	Distance
Trunk	☐	☐		
Lift/Pump Station	☐	☐		
WWTP	☐	☐		
Other	☐	☐		

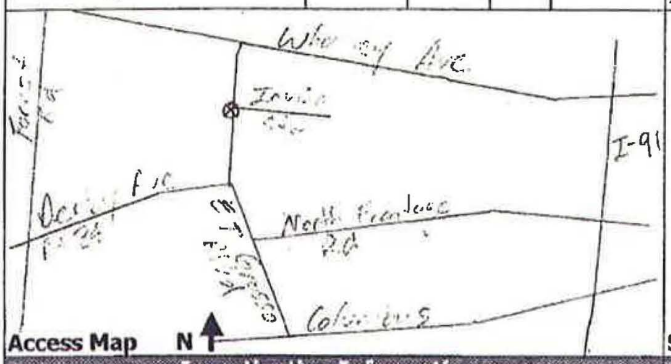
Additional Site Information/Comments:

GNH0016-097

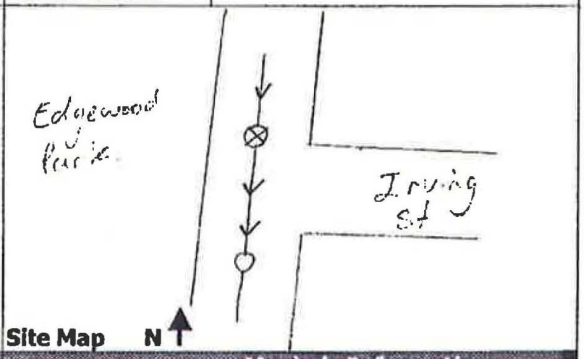
ADS ENVIRONMENTAL SERVICES

ADS Site Report — Quality Form

Project Name:	[illegible]			City/State:	New Haven, CT	FM Initials:	CF
Site Name:	CSO-SS 5	Monitor Series:	4000	Monitor S/N:			
Address / Location:	Middle of [illegible] at Irving Place.			Manhole #:			
				Map Page #:			
Access:	Drive.	Type of System:	Sanitary ☐ Storm ☐ Combined ☒	Pipe Height:	59.00"		
				Pipe Width:	61.25"		
				Phone Number:			



Access Map N



Site Map N

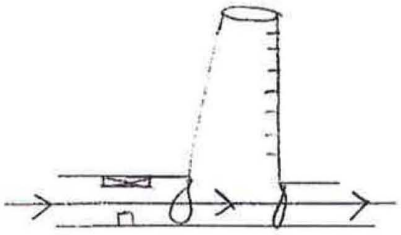
Investigation Information:

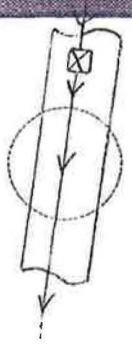
Date/ Time of Investigation:	4/27
Site Hydraulics:	Smooth, deep, flow
Upstream Input: (L/S, P/S)	NA
Upstream Manhole:	DNI
Downstream Manhole:	Does not [illegible]
Depth of Flow (Wet Dof):	27.50 +/-
Range (Air Dof):	30.50 +/-
Peak Velocity:	1.50 fps
Silt:	2.50 Inches

Manhole Information:

Manhole Depth:	22 Feet			
Manhole Material / Condition:	Brick / Fair			
Pipe Material / Condition:	Brick [illegible]			
Mini System Character:	Residential ☒	Commercial ☐	Industrial ☐	Other
Telephone Information:	–			
Access Pole #:	–			
Distance From Manhole:	-- Feet			
Road Cut Length:	-- Feet			
Trench Length:	. Feet			

Other Information


Cross Section N


Planar N

Installation Information	
Installation Type:	Sewer Install
Sensors/Devices:	Ultra, V2 + Press
Surcharge Height:	6 Feet
Rain Gauge Zone:	RG-2

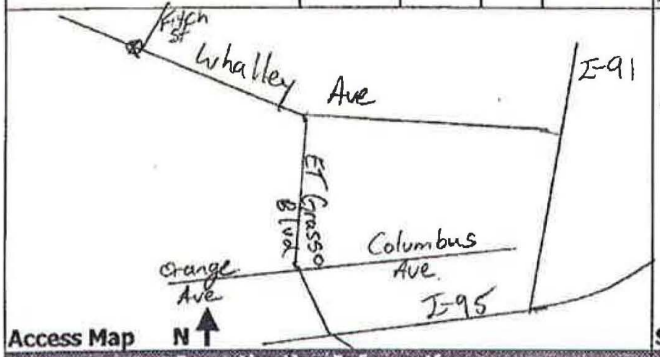
Backup	Yes	No	?	Distance
Trunk	☐	☒		
Lift/Pump Station	☐	☒		
WWTP	☐	☒		
Other	☐	☒		

Additional Site Information/Comments:

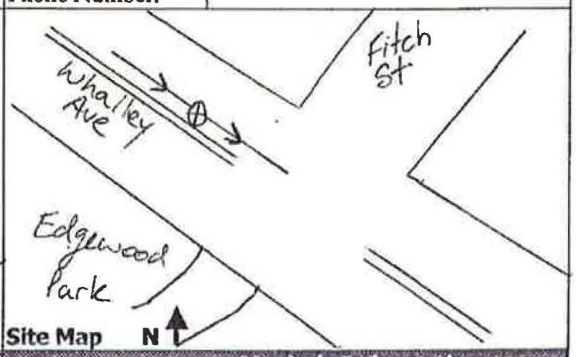
ADS ENVIRONMENTAL SERVICES

ADS Site Report — Quality Form

Project Name: New Haven TFM			City/State: New Haven, CT			FM Initials: GE	
Site Name: CSO-006	Monitor Series: 3500			Monitor S/N:	6243		
Address / Location: In left lane Whalley Ave past Fitch St.				Manhole #:			
				Map Page #:			
Access: Drive	Type of System:	Sanitary ☐	Storm ☐	Combined ☒	Pipe Height:	56.00	
					Pipe Width:	60.25	
					Phone Number:		



Access Map



Site Map

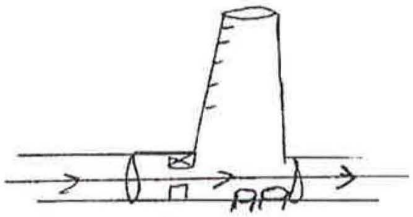
Investigation Information:

Date/ Time of Investigation:	4/11/07
Site Hydraulics:	Slow, Smooth flow
Upstream Input: (I./S, P/S)	NA
Upstream Manhole:	Did not Investigate
Downstream Manhole:	DVI
Depth of Flow (Wet Dof):	28.50 +/-
Range (Air Dof):	27.50 +/-
Peak Velocity:	1.30 fps
Silt:	17.50 Inches

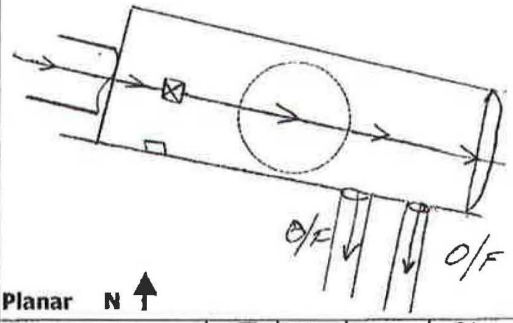
Manhole Information:

Manhole Depth:	9 Feet				
Manhole Material / Condition:	Brick / Fair				
Pipe Material / Condition:	Brick Fair				
Mini System Character:	Residential ☒	Commercial ☒	Industrial ☐	Other	
Telephone Information:	—				
Access Pole #:	—				
Distance From Manhole:	— Feet				
Road Cut Length:	— Feet				
Trench Length:	— Feet				

Other Information



Cross Section



Planar

Installation Information	
Installation Type:	Special Install
Sensors/Devices:	Ultra, Vel + Press
Surcharge Height:	Feet
Rain Gauge Zone:	RG-2

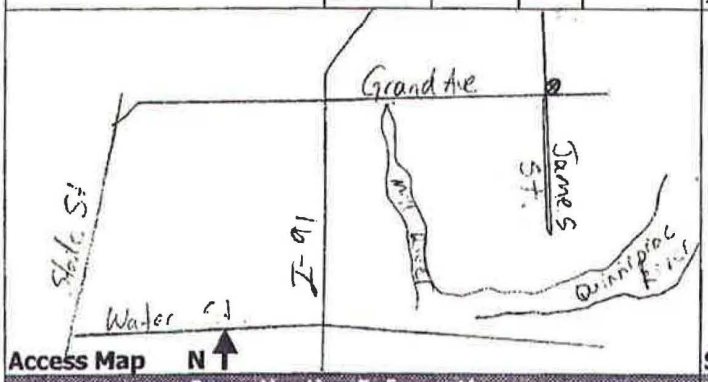
Backup	Yes	No	?	Distance
Trunk	☐	☒		
Lift/Pump Station	☐	☒		
WWTP	☐	☒		
Other	☐	☒		

Additional Site Information/Comments:

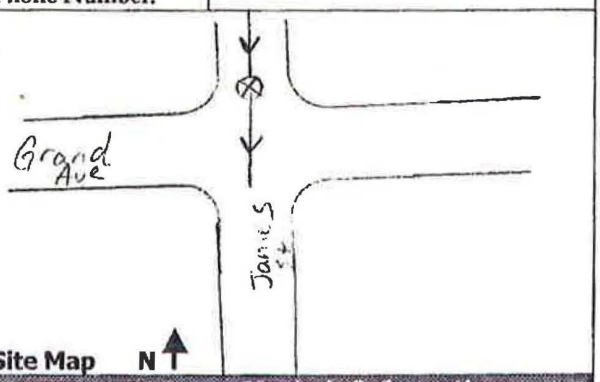
ADS ENVIRONMENTAL SERVICES

ADS Site Report — Quality Form

Project Name: New Haven TFM			City/State: New Haven CT		FM Initials: GE.	
Site Name: CSO-009	Monitor Series: 3500			Monitor S/N:	3872	
Address / Location: Intersection of James + and Grand Ave. 2 crossroads.				Manhole #:		
				Map Page #:		
Access: Drive.	Type of System:	Sanitary ☐	Storm ☐	Combined ☒	Pipe Height:	53.00"
					Pipe Width:	35.00"
					Phone Number:	



Access Map N



Site Map N

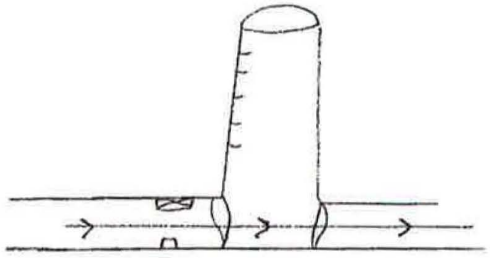
Investigation Information:

Date/ Time of Investigation:	9/10/07	10:30.	
Site Hydraulics:	Deep Moderate flows.		
Upstream Input: (L/S, P/S)	NA		
Upstream Manhole:	Bad Hydraulics		
Downstream Manhole:	[illegible]		
Depth of Flow (Wet Dof):	23.25	+/-	
Range (Air Dof):	28.75	+/-	
Peak Velocity:	0.96.	fps	
Silt:	2.00	Inches	

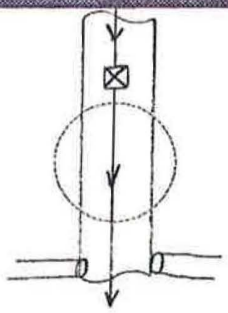
Manhole Information:

Manhole Depth:	20	Feet			
Manhole Material / Condition:	Concrete Fair				
Pipe Material / Condition:	Brick Fair				
Mini System Character:	Residential ☒	Commercial ☒	Industrial ☐	Other	
Telephone Information:	–				
Access Pole #:	–				
Distance From Manhole:	–	Feet			
Road Cut Length:	–	Feet			
Trench Length:	–	Feet			

Other Information



Cross Section N



Planar N

Installation Information		Backup	Yes	No	?	Distance
Installation Type:	Special Tank	Trunk	☐	☒		
Sensors/Devices:	Ultra, Vel + Press	Lift/Pump Station	☐	☒		
Surcharge Height:	No Feet	WWTP	☐	☒		
Rain Gauge Zone:		Other	☐	☒		

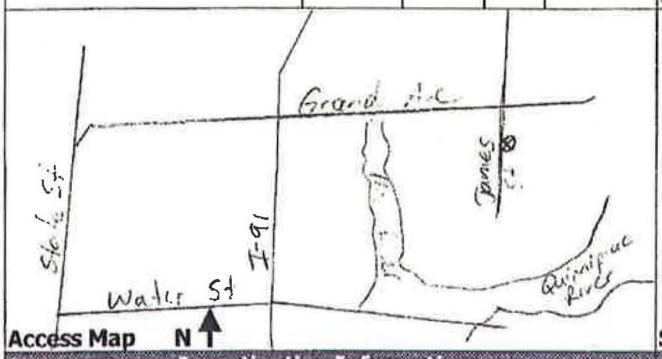
Additional Site Information/Comments:

GNH0016-100

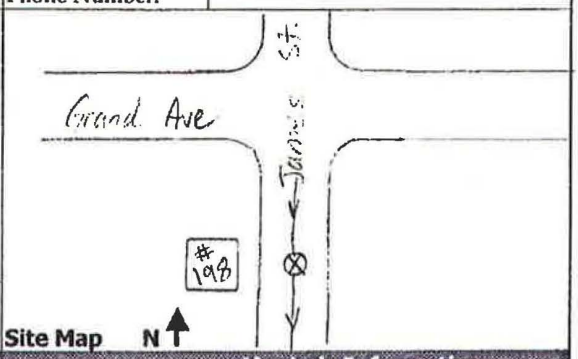
ADS ENVIRONMENTAL SERVICES

ADS Site Report — Quality Form

Project Name: New Haven TMH				City/State: New Haven CT		FM Initials: CC	
Site Name: CSO-009A	Monitor Series: 3500			Monitor S/N:	6150		
Address / Location: James St. Grand #198 James				Manhole #:			
				Map Page #:			
Access: Drive	Type of System:	Sanitary ☐	Storm ☐	Combined ☒	Pipe Height:	96.25	
					Pipe Width:	30.25"	
					Phone Number:		



Access Map N



Site Map N

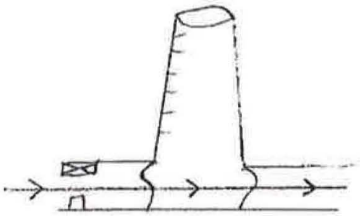
Investigation Information:

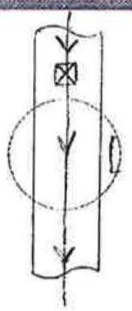
Date/ Time of Investigation:	4/10/07 10:30		
Site Hydraulics:	Smooth, Moderate Flow		
Upstream Input: (I./S, P/S)	Headwall		
Upstream Manhole:	Does not Include.		
Downstream Manhole:	DNE		
Depth of Flow (Wet Dof):	20.00 +/-		
Range (Air Dof):	2600 +/-		
Peak Velocity:	2.02. fps		
Silt:	10.50 Inches		

Manhole Information:

Manhole Depth:	23' Feet				
Manhole Material / Condition:	Brick Fair				
Pipe Material / Condition:	Brick - Fair				
Mini System Character:	Residential ☒	Commercial ☒	Industrial ☐	Other	
Telephone Information:	-				
Access Pole #:	-				
Distance From Manhole:	- Feet				
Road Cut Length:	- Feet				
Trench Length:	- Feet				

Other Information


Cross Section N


Planar N

Installation Information	
Installation Type:	Special Handhole
Sensors/Devices:	Ultra Vel + Press
Surcharge Height:	15' Feet
Rain Gauge Zone:	

Backup	Yes	No	?	Distance
Trunk	☐	☒		
Lift/Pump Station	☐	☒		
WWTP	☐	☒		
Other	☐	☒		

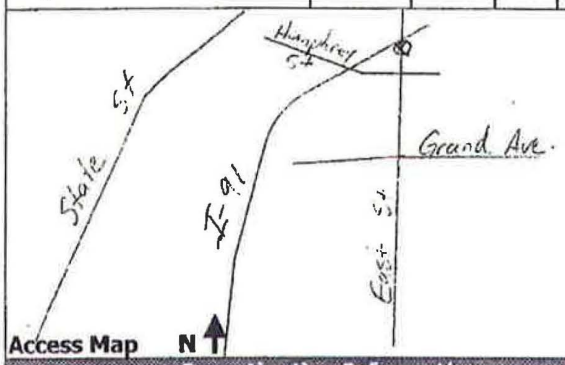
Additional Site Information/Comments:

GNH0016-101

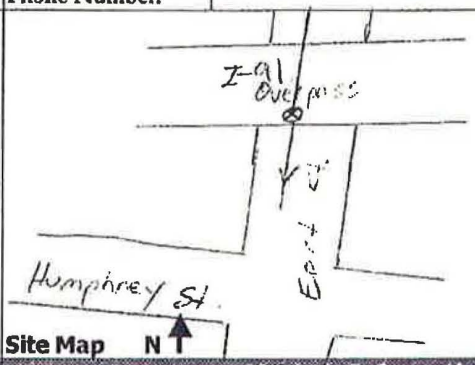
ADS ENVIRONMENTAL SERVICES

ADS Site Report — Quality Form

Project Name: New Haven TFM				City/State: New Haven, CT		FM Initials: GE
Site Name: CSO - 010.	Monitor Series: 3500			Monitor S/N:	6101	
Address / Location: On East St - under I-91 over pass.				Manhole #:		
				Map Page #:		
Access: Drive	Type of System:	Sanitary ☐	Storm ☐	Combined ☒	Pipe Height:	47.25
					Pipe Width:	47.50
					Phone Number:	



Access Map N



Site Map N

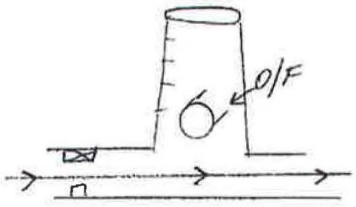
Investigation Information:

Date/ Time of Investigation:	4/11/07
Site Hydraulics:	Smooth. fast Flow.
Upstream Input: (L/S, P/S)	NA
Upstream Manhole:	NA
Downstream Manhole:	DNI
Depth of Flow (Wet Dof):	13.75 +/-
Range (Air Dof):	33.50 +/-
Peak Velocity:	2.70 fps
Silt:	☒ Inches

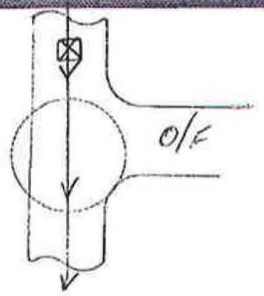
Manhole Information:

Manhole Depth:	19 Feet				
Manhole Material / Condition:	Brick / Concrete Fair				
Pipe Material / Condition:	Brick - Fair				
Mini System Character:	Residential ☒	Commercial ☒	Industrial ☐	Other	
Telephone Information:	—				
Access Pole #:	—				
Distance From Manhole:	-- Feet				
Road Cut Length:	— Feet				
Trench Length:	— Feet				

Other Information



Cross Section N



Planar N

Installation Information	
Installation Type:	Special
Sensors/Devices:	1 Ultra Vel + Press
Surcharge Height:	8 Feet
Rain Gauge Zone:	

Backup	Yes	No	?	Distance
Trunk	☐	☒		
Lift/Pump Station	☐	☒		
WWTP	☐	☒		
Other	☐	☒		

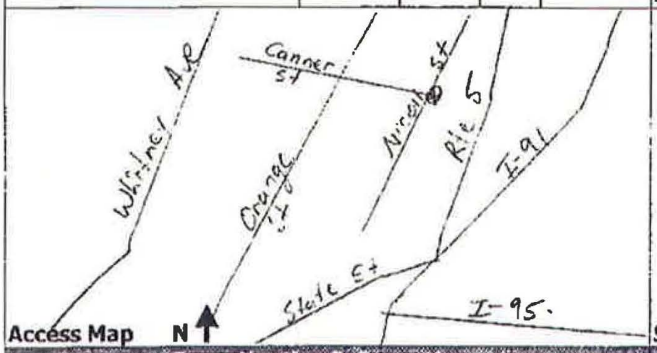
Additional Site Information/Comments:

GNH0016-102

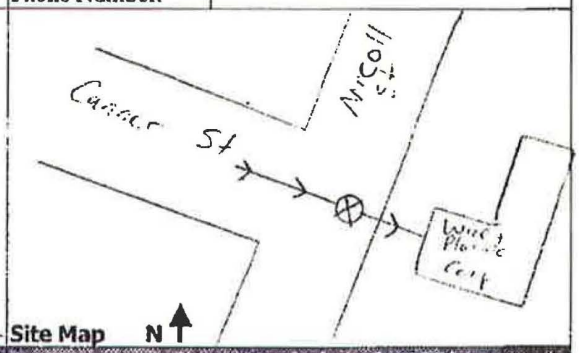
ADS ENVIRONMENTAL SERVICES

ADS Site Report — Quality Form

Project Name: New Haven TFM				City/State: New Haven CT		FM Initials: GE
Site Name: C50-012	Monitor Series: 1502			Monitor S/N:	8845	
Address / Location: Intersection of Canner St and Nicoll St. Outside # 265 Nicoll				Manhole #:		
				Map Page #:		
Access: Drive	Type of System:	Sanitary ☐	Storm ☐	Combined ☒	Pipe Height:	47.13"
					Pipe Width:	50.00
					Phone Number:	



Access Map N



Site Map N

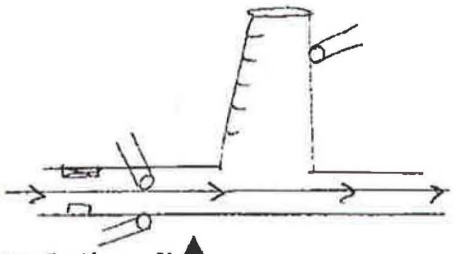
Investigation Information

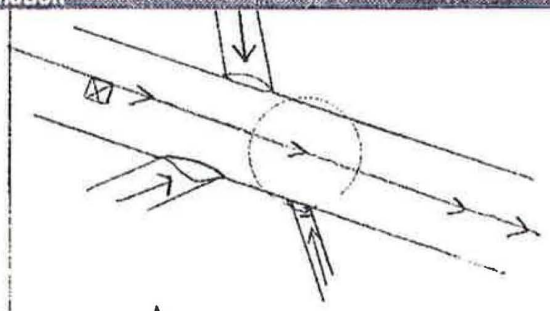
Date/ Time of Investigation:	4/11/07
Site Hydraulics:	Deep, Full flow. Small waves.
Upstream Input: (L/S, P/S)	NA
Upstream Manhole:	Did not Investigate
Downstream Manhole:	ONE
Depth of Flow (Wet Dof):	22.00 +/-
Range (Air Dof):	25.00 +/-
Peak Velocity:	2.68 fps
Silt:	0 Inches

Manhole Information

Manhole Depth:	12	Feet			
Manhole Material / Condition:	Brick / Fair				
Pipe Material / Condition:	Brick / Poor				
Mini System Character:	Residential ☒	Commercial ☒	Industrial ☐	Other	
Telephone Information:	—				
Access Pole #:	—				
Distance From Manhole:	—	Feet			
Road Cut Length:	—	Feet			
Trench Length:	—	Feet			

Other Information


Cross Section N


Planar N

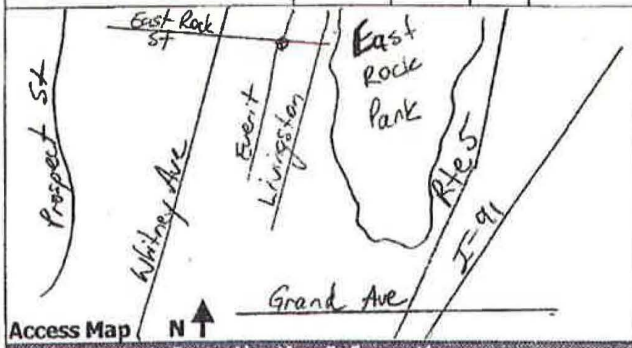
Installation Information		Backup	Yes	No	?	Distance
Installation Type:	Special Manhole	Trunk	☐	☒		
Sensors/Devices:	Ultra, Vel + Press	Lift/Pump Station	☐	☒		
Surcharge Height:	5 Feet	WWTP	☐	☒		
Rain Gauge Zone:	RG-3	Other	☐	☒		

Additional Site Information/Comments:

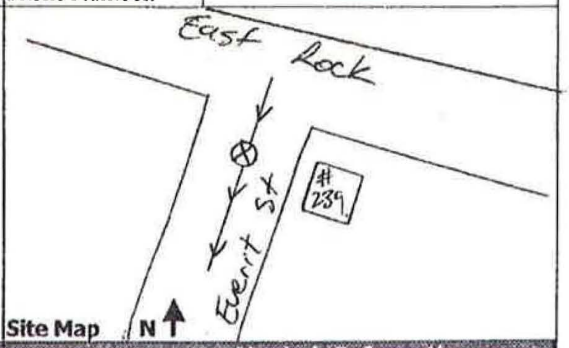
ADS ENVIRONMENTAL SERVICES

ADS Site Report — Quality Form

Project Name: New Haven TFM		City/State: New Haven, CT			FM Initials: GE	
Site Name: CSO-013	Monitor Series: 3500		Monitor S/N:	6404		
Address / Location: Outside #239 Everit St. At East Rock St.			Manhole #:			
			Map Page #:			
Access: Drive	Type of System:	Sanitary ☒ Storm ☐ Combined ☐	Pipe Height:	45.50"		
			Pipe Width:	31.00"		
			Phone Number:			



Access Map



Site Map

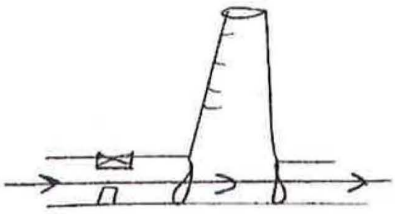
Investigation Information:

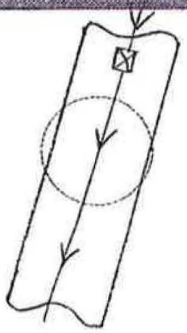
Date/ Time of Investigation:	4/11/09
Site Hydraulics:	Slow, Smooth flow.
Upstream Input: (L/S, P/S)	NA
Upstream Manhole:	DNI
Downstream Manhole:	DNI
Depth of Flow (Wet Dof):	12.50. +/-
Range (Air Dof):	33.00 +/-
Peak Velocity:	0.70 fps
Silt:	7.00. Inches

Manhole Information:

Manhole Depth:	.14	Feet		
Manhole Material / Condition:	Brick Fair			
Pipe Material / Condition:	Brick - Poor.			
Mini System Character:	Residential ☒	Commercial ☐	Industrial ☐	Other
Telephone Information:	—			
Access Pole #:	—			
Distance From Manhole:	— Feet			
Road Cut Length:	— Feet			
Trench Length:	— Feet			

Other Information


Cross Section N


Planar N

Installation Information	
Installation Type:	Special Install
Sensors/Devices:	Ultra, Vel + Press
Surcharge Height:	NO Feet
Rain Gauge Zone:	RG-2

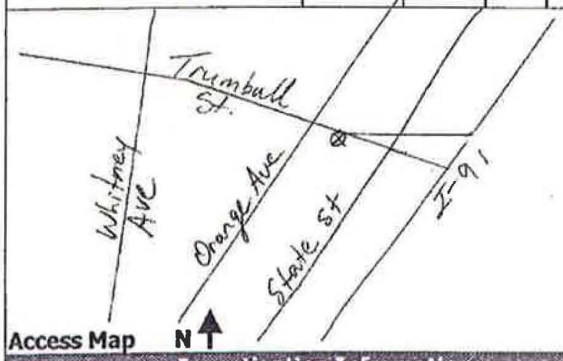
Backup	Yes	No	?	Distance
Trunk	☐	☒		
Lift/Pump Station	☐	☒		
WWTP	☐	☒		
Other	☐	☒		

Additional Site Information/Comments:

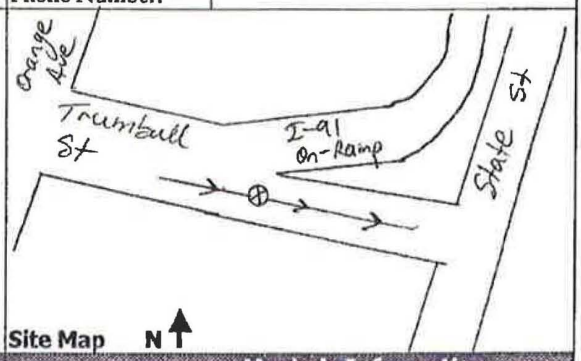
ADS ENVIRONMENTAL SERVICES

ADS Site Report — Quality Form

Project Name: New Haven TFM				City/State: New Haven, CT		FM Initials: GE	
Site Name: CSO-014.	Monitor Series: 3500			Monitor S/N:	6400		
Address / Location: On Trumbull St - East of Orange Ave. I-91 On-Ramp.				Manhole #:			
Access: Drive.	Type of System:	Sanitary ☐	Storm ☐	Combined ☒	Map Page #:		
					Pipe Height:	66.50"	
					Pipe Width:	68.00	
					Phone Number:		



Access Map



Site Map

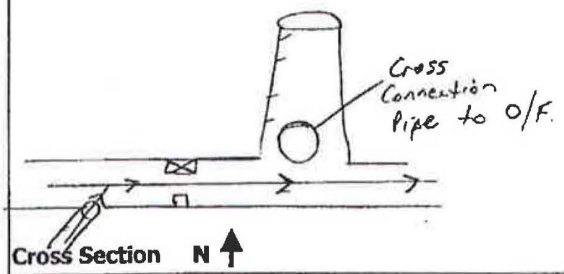
Investigation Information:

Date/ Time of Investigation:	4/10/07				
Site Hydraulics:	Wavy, fast flow.				
Upstream Input: (I./S, P/S)	NA				
Upstream Manhole:	DNI				
Downstream Manhole:	DNI				
Depth of Flow (Wet Dof):	9.50	+/-			
Range (Air Dof):	57.00	+/-			
Peak Velocity:	3.02	fps			
Silt:	0	Inches			

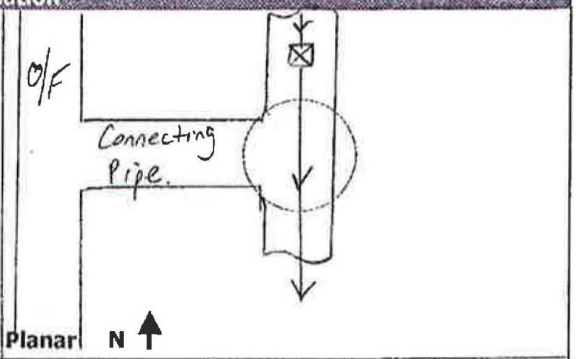
Manhole Information:

Manhole Depth:	12	Feet			
Manhole Material / Condition:	Brick / Fair				
Pipe Material / Condition:	Brick - Poor				
Mini System Character:	Residential ☒	Commercial ☒	Industrial ☐	Other	
Telephone Information:	—				
Access Pole #:	—				
Distance From Manhole:	—	Feet			
Road Cut Length:	—	Feet			
Trench Length:	—	Feet			

Other Information



Cross Section



Planar

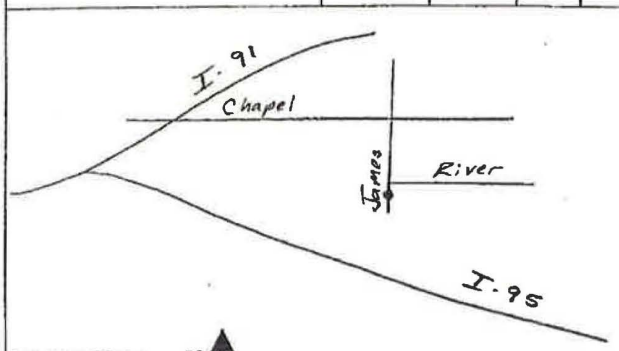
Installation Information		Backup	Yes	No	?	Distance
Installation Type:	Special	Trunk	☐	☒		
Sensors/Devices:	Ultra, Vel + Press	Lift/Pump Station	☐	☒		
Surcharge Height:	Feet	WWTP	☐	☒		
Rain Gauge Zone:		Other	☐	☒		

Additional Site Information/Comments:

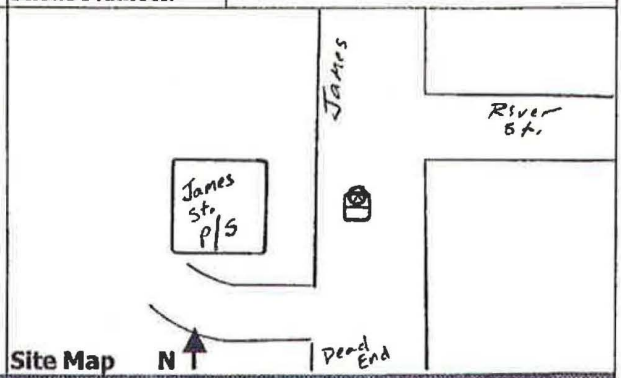
ADS ENVIRONMENTAL SERVICES

ADS Site Report — Quality Form

Project Name: New Haven TFM			City/State: New Haven CT			FM Initials: GE	
Site Name: CSO-015	Monitor Series: 3500			Monitor S/N:	4636		
Address / Location: End of James St. South of River St				Manhole #:			
				Map Page #:			
Access: Drive	Type of System:	Sanitary ☐	Storm ☐	Combined ☒	Pipe Height:	45.75	
					Pipe Width:	46.25	
					Phone Number:		



Access Map N



Site Map N

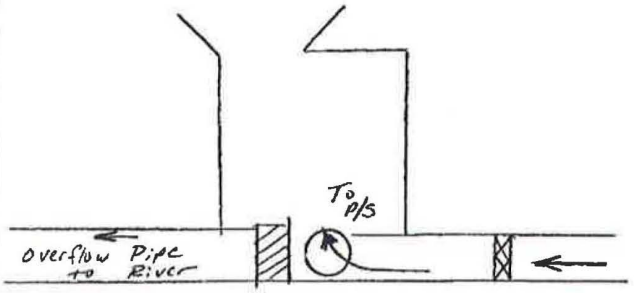
Investigation Information:

Date/ Time of Investigation:	4/10 - 4/10
Site Hydraulics:	Good Smooth Flow with Moderate Velocity
Upstream Input: (L/S, P/S)	N/A
Upstream Manhole:	DNI
Downstream Manhole:	Wet Well
Depth of Flow (Wet Dof):	11.5 +/-
Range (Air Dof):	+/-
Peak Velocity:	1.67 fps
Silt:	Ø Inches

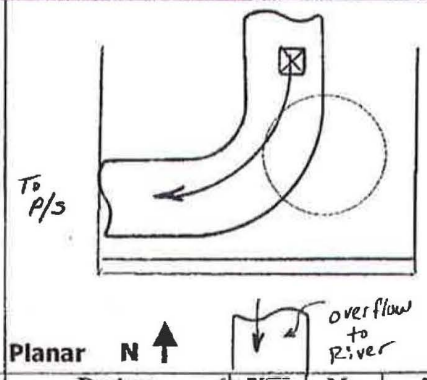
Manhole Information:

Manhole Depth:	9.Ø	Feet		
Manhole Material / Condition:	Concrete / Fair			
Pipe Material / Condition:	Brick / Fair			
Mini System Character:	Residential ☒	Commercial ☒	Industrial ☒	Other
Telephone Information:	N/A			
Access Pole #:				
Distance From Manhole:		Feet		
Road Cut Length:		Feet		
Trench Length:		Feet		

Other Information



Cross Section N



Planar N

Installation Information		Backup	Yes	No	?	Distance
Installation Type:		Trunk	☐	☐		
Sensors/Devices:		Lift/Pump Station	☐	☐		
Surcharge Height:	Feet	WWTP	☐	☐		
Rain Gauge Zone:		Other	☐	☐		

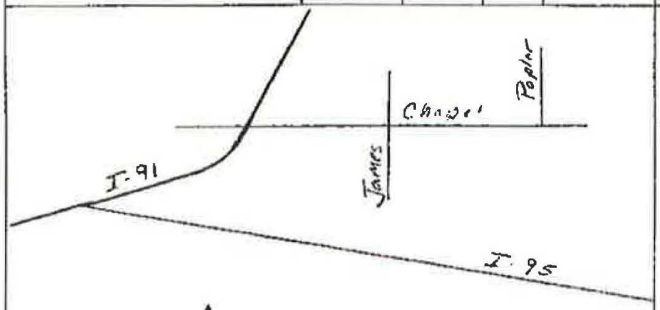
Additional Site Information/Comments:

Large Square hatch doors to Access M/H

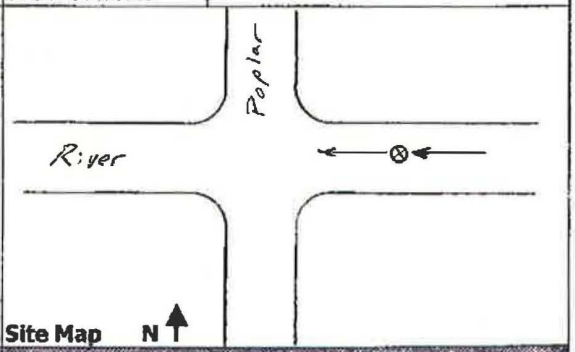
ADS ENVIRONMENTAL SERVICES

ADS Site Report — Quality Form

Project Name: New Haven TFM				City/State: New Haven CT		FM Initials: GE	
Site Name: CSO. Ø16	Monitor Series: 3500			Monitor S/N:	6365		
Address / Location: River St. East of Poplar				Manhole #:			
				Map Page #:			
Access: Drive	Type of System:	Sanitary ☐	Storm ☐	Combined ☒	Pipe Height:	42.38	
					Pipe Width:	42.38	
					Phone Number:		



Access Map N



Site Map N

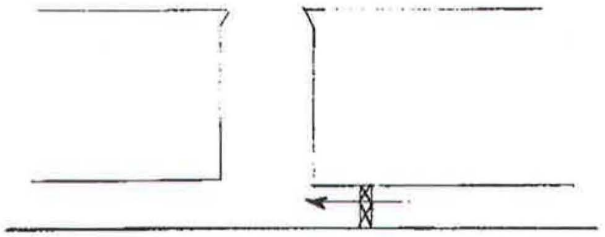
Investigation Information:

Date/ Time of Investigation:	4/10 - 4/11		
Site Hydraulics:	Shallow, very slow flow		
Upstream Input: (L/S, P/S)	N/A		
Upstream Manhole:	DNI		
Downstream Manhole:	DNI		
Depth of Flow (Wet Dof):	1.75 +/-		
Range (Air Dof):	+/-		
Peak Velocity:	Ø.50 fps		
Silt:	16.Ø Inches		

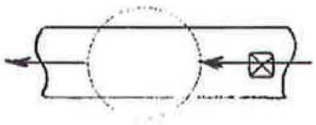
Manhole Information:

Manhole Depth:	7 Feet				
Manhole Material / Condition:	Brick / Poor				
Pipe Material / Condition:	Brick / Poor				
Mini System Character:	Residential ☒	Commercial ☒	Industrial ☒	Other	
Telephone Information:	N/A				
Access Pole #:					
Distance From Manhole:	Feet				
Road Cut Length:	Feet				
Trench Length:	Feet				

Other Information



Cross Section N



Planar N

Installation Information		Backup	Yes	No	?	Distance
Installation Type:	Special	Trunk	☐	☒		
Sensors/Devices:	UVP	Lift/Pump Station	☐	☒		
Surcharge Height:	Feet	WWTP	☐	☒		
Rain Gauge Zone:		Other	☐	☐		

Additional Site Information/Comments:

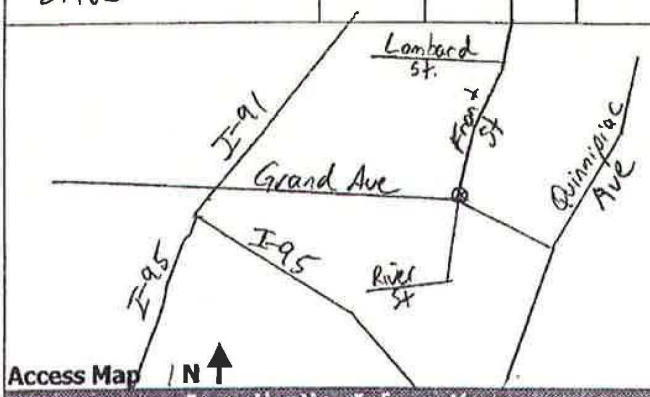
In River St in front of Scrap Metal Yard

GNH0016-107

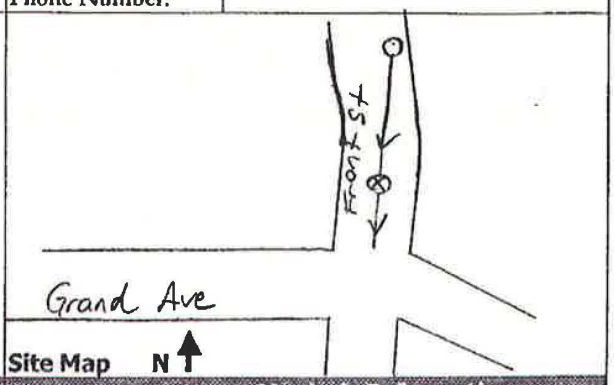
ADS ENVIRONMENTAL SERVICES

ADS Site Report — Quality Form

Project Name: New Haven TFM				City/State: New Haven, CT		FM Initials: GE	
Site Name: CSO-017	Monitor Series: 3500			Monitor S/N:	6287		
Address / Location: Front St 50ft North of Grand Ave Intersection.				Manhole #:			
				Map Page #:			
Access: Drive	Type of System:	Sanitary ☐	Storm ☐	Combined ☒	Pipe Height:	28.50"	
					Pipe Width:	48.50"	
					Phone Number:		



Access Map N



Site Map N

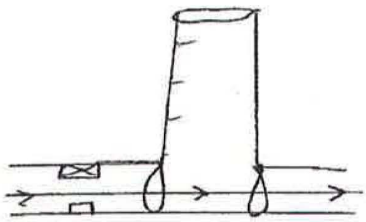
Investigation Information:

Date/ Time of Investigation:	4/11/07
Site Hydraulics:	Sluggish, Shallow flow
Upstream Input: (L/S, P/S)	NA
Upstream Manhole:	Not Suitable
Downstream Manhole:	As current site.
Depth of Flow (Wet Dof):	+/-
Range (Air Dof):	+/-
Peak Velocity:	fps
Silt:	Inches

Manhole Information:

Manhole Depth:	8	Feet			
Manhole Material / Condition:	Brick / Fair				
Pipe Material / Condition:	Brick - Fair				
Mini System Character:	Residential ☒	Commercial ☒	Industrial ☐	Other	
Telephone Information:	—				
Access Pole #:	—				
Distance From Manhole:	—	Feet			
Road Cut Length:	—	Feet			
Trench Length:	—	Feet			

Other Information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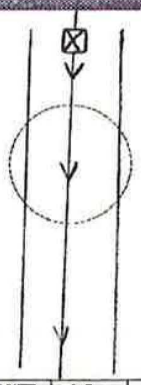

Planar N

Installation Information	
Installation Type:	Special
Sensors/Devices:	Ultra, Vel + Press
Surcharge Height:	Feet
Rain Gauge Zone:	

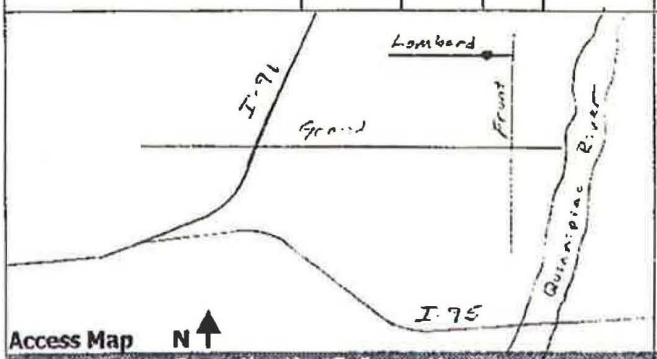
Backup	Yes	No	?	Distance
Trunk	☐	☒		
Lift/Pump Station	☐	☒		
WWTP	☐	☒		
Other	☐	☒		

Additional Site Information/Comments:

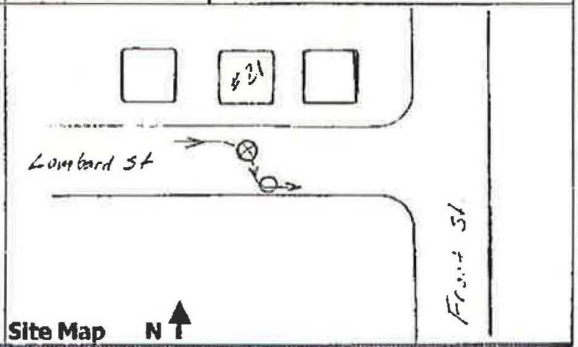
ADS ENVIRONMENTAL SERVICES

ADS Site Report — Quality Form

Project Name: New Haven TFM				City/State: New Haven CT		FM Initials: GE	
Site Name: CSO-018	Monitor Series: 3500			Monitor S/N:	4773		
Address / Location: 21 Lombard St.				Manhole #:			
				Map Page #:			
Access: Drive	Type of System:	Sanitary ☐	Storm ☐	Combined ☒	Pipe Height:	45.63	
					Pipe Width:	30.38	
					Phone Number:		



Access Map N



Site Map N

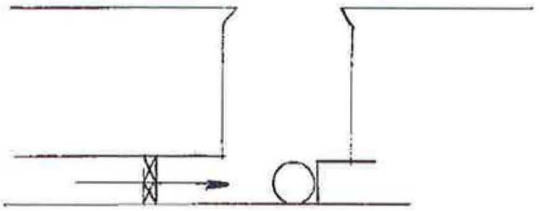
Investigation Information:

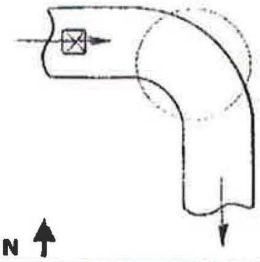
Date/ Time of Investigation:	4/10 - 4/11
Site Hydraulics:	Shallow, Fast Flow
Upstream Input: (I./S, P/S)	N/A
Upstream Manhole:	DNI
Downstream Manhole:	N/A
Depth of Flow (Wet Dof):	2.0 +/-
Range (Air Dof):	+/-
Peak Velocity:	3.18 fps
Silt:	ø Inches

Manhole Information:

Manhole Depth:	7.5 Feet				
Manhole Material / Condition:	Brick / Good				
Pipe Material / Condition:	Brick / Good				
Mini System Character:	Residential ☒	Commercial ☒	Industrial ☐	Other	
Telephone Information:	N/A				
Access Pole #:					
Distance From Manhole:	Feet				
Road Cut Length:	Feet				
Trench Length:	Feet				

Other Information


Cross Section N


Planar N

Installation Information	
Installation Type:	Special
Sensors/Devices:	UVP
Surcharge Height:	Feet
Rain Gauge Zone:	

Backup	Yes	No	?	Distance
Trunk	☐	☒		
Lift/Pump Station	☐	☒		
WWTP	☐	☒		
Other	☐	☐		

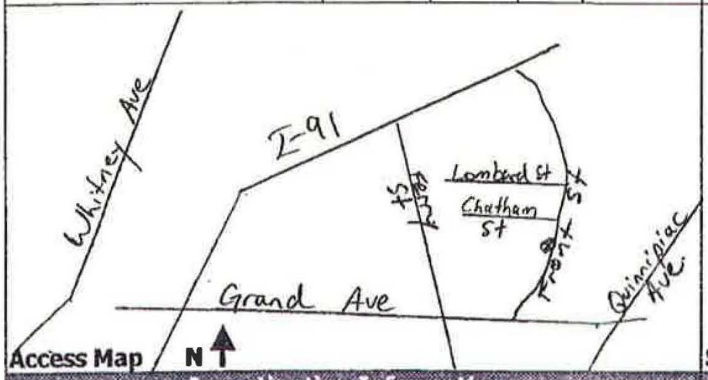
Additional Site Information/Comments:

GNH0016-109

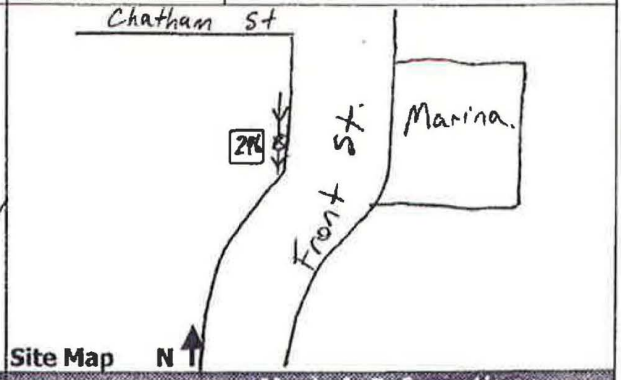
ADS ENVIRONMENTAL SERVICES

ADS Site Report — Quality Form

Project Name: New Haven, TFM			City/State: New Haven, CT			FM Initials: GE	
Site Name: CSO-019.	Monitor Series: 3500			Monitor S/N:	4646		
Address / Location: In sidewalk outside #296 Front St.				Manhole #:			
				Map Page #:			
Access: Drive	Type of System:	Sanitary ☐	Storm ☐	Combined ☒	Pipe Height:	30.25"	
					Pipe Width:	30.25"	
					Phone Number:		



Access Map N



Site Map N

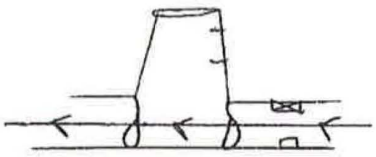
Investigation Information:

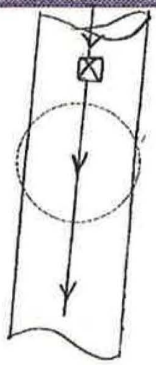
Date/ Time of Investigation:	4/11/07
Site Hydraulics:	Slow, Sluggish flow
Upstream Input: (L/S, P/S)	NA
Upstream Manhole:	DNI
Downstream Manhole:	DNI
Depth of Flow (Wet Dof):	7.00 +/-
Range (Air Dof):	23.00 +/-
Peak Velocity:	0.45 fps
Silt:	1/2" Inches

Manhole Information:

Manhole Depth:	4 Feet			
Manhole Material / Condition:	Concrete / Brick Fair			
Pipe Material / Condition:	Ductile Iron Pipe			
Mini System Character:	Residential ☒	Commercial ☒	Industrial ☐	Other
Telephone Information:	—			
Access Pole #:	—			
Distance From Manhole:	— Feet			
Road Cut Length:	— Feet			
Trench Length:	— Feet			

Other Information


Cross Section N


Planar N

Installation Information	
Installation Type:	Ring + Crank
Sensors/Devices:	Ultra, Vel + Press
Surcharge Height:	2. Feet
Rain Gauge Zone:	RG-3

Backup	Yes	No	?	Distance
Trunk	☐	☒		
Lift/Pump Station	☐	☒		
WWTP	☐	☒		
Other	☐	☒		

Additional Site Information/Comments:

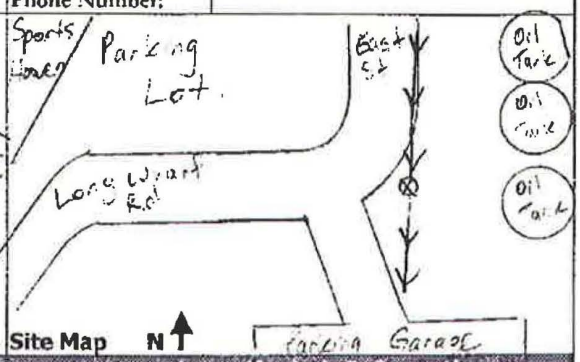
GNH0016-110

ADS ENVIRONMENTAL SERVICES

ADS Site Report — Quality Form

Project Name: New Haven TFM			City/State: New Haven, CT		FM Initials: GE
Site Name: CSO- 021	Monitor Series: 3500		Monitor S/N:	5376	
Address / Location: East St at Long Wharf Rd. At Entrance to Parking Garage & Grass			Manhole #:		
			Map Page #:		
Access: Drive	Type of System:	Sanitary ☐	Storm ☐	Combined ☒	Pipe Height: 60.00"
					Pipe Width: 60.00"
					Phone Number:

Access Map N



Site Map N

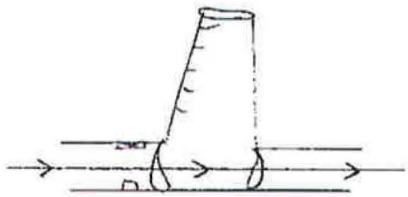
Investigation Information:

Date/ Time of Investigation:	4/10/07
Site Hydraulics:	Deep, Stable Flow
Upstream Input: (I./S, P/S)	NA
Upstream Manhole:	Did not Investigate
Downstream Manhole:	DAF - Unavailable
Depth of Flow (Wet Dof):	4/ +/-
Range (Air Dof):	19.60 +/-
Peak Velocity:	1.50 fps
Silt:	0 Inches

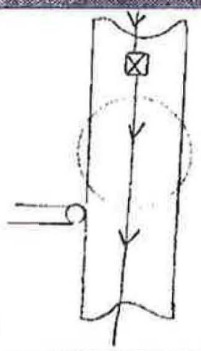
Manhole Information:

Manhole Depth:	12' Feet				
Manhole Material / Condition:	Brick / Poor				
Pipe Material / Condition:	Brick / Fair				
Mini System Character:	Residential ☐	Commercial ☒	Industrial ☒	Other	
Telephone Information:	—				
Access Pole #:	—				
Distance From Manhole:	-- Feet				
Road Cut Length:	— Feet				
Trench Length:	— Feet				

Other Information



Cross Section N



Planar N

Installation Information		Backup	Yes	No	?	Distance
Installation Type:	Special Install	Trunk	☐	☒		
Sensors/Devices:	Ultra, Vel + Press	Lift/Pump Station	☒	☐		
Surcharge Height:	11 Feet	WWTP	☐	☒		
Rain Gauge Zone:	RG-1	Other	☐	☒		

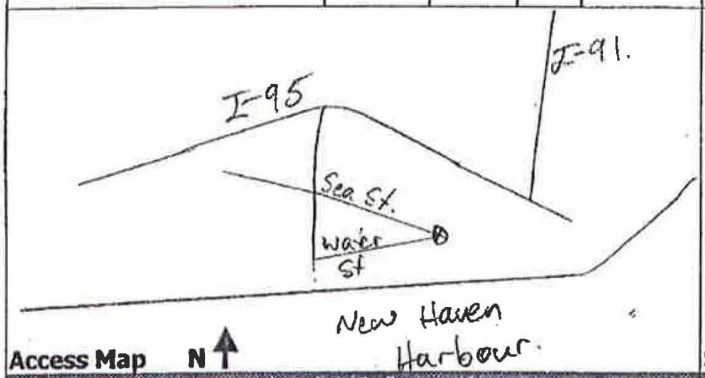
Additional Site Information/Comments:

GNH0016-111

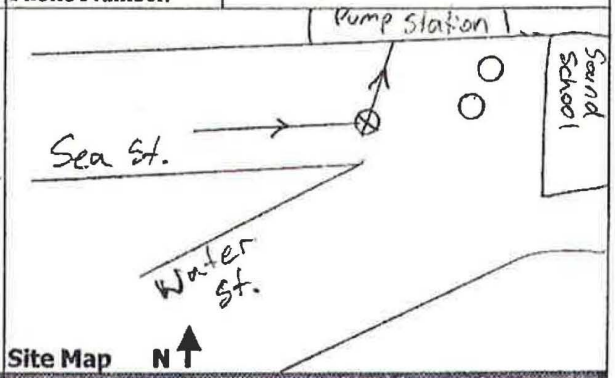
ADS ENVIRONMENTAL SERVICES

ADS Site Report — Quality Form

Project Name: New Haven TFM.	City/State: New Haven CT	FM Initials: GE.				
Site Name: CSO-024	Monitor Series: 3500	Monitor S/N: 4639				
Address / Location: Sea St. @ Water St. In roadway		Manhole #:				
		Map Page #:				
Access: Drive.	Type of System: Sanitary ☐ Storm ☐ Combined ☒	Pipe Height: 69.75				
		Pipe Width: 85.00.				
		Phone Number:				



Access Map N



Site Map N

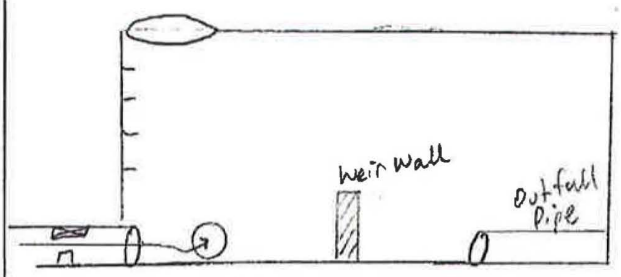
Investigation Information:

Date/ Time of Investigation:	4/11/07
Site Hydraulics:	Deep fast smooth flow.
Upstream Input: (I/S, P/S)	NA
Upstream Manhole:	DNI
Downstream Manhole:	Pump Station.
Depth of Flow (Wet Dof):	28 +/-
Range (Air Dof):	41 +/-
Peak Velocity:	3.20 fps
Silt:	1.0" Inches

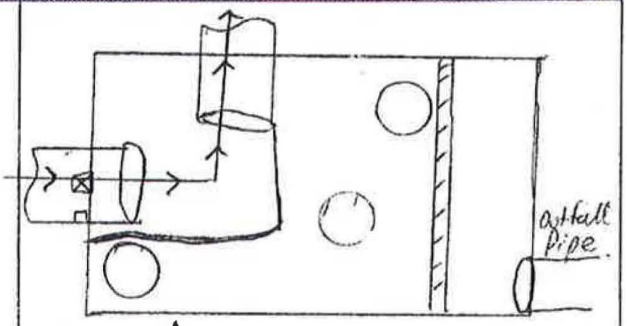
Manhole Information:

Manhole Depth:	10	Feet			
Manhole Material / Condition:	Concrete. Fair				
Pipe Material / Condition:	Brick - Poor.				
Mini System Character:	Residential ☒	Commercial ☐	Industrial ☐	Other	
Telephone Information:	—				
Access Pole #:	—				
Distance From Manhole:	—	Feet			
Road Cut Length:	—	Feet			
Trench Length:	—	Feet			

Other Information



Cross Section N



Planar N

Installation Information		Backup	Yes	No	?	Distance
Installation Type:	Special	Trunk	☐	☒		
Sensors/Devices:	Ultra, Vel + Press	Lift/Pump Station	☐	☒		
Surcharge Height:	10ft. Feet	WWTP	☐	☒		
Rain Gauge Zone:	RG-1	Other	☐	☒		

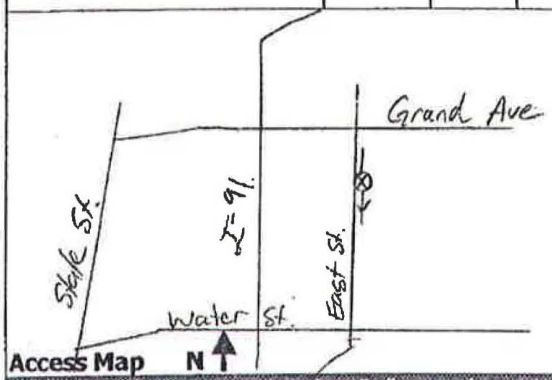
Additional Site Information/Comments:

1"-2" of silt on left side of pipe only.

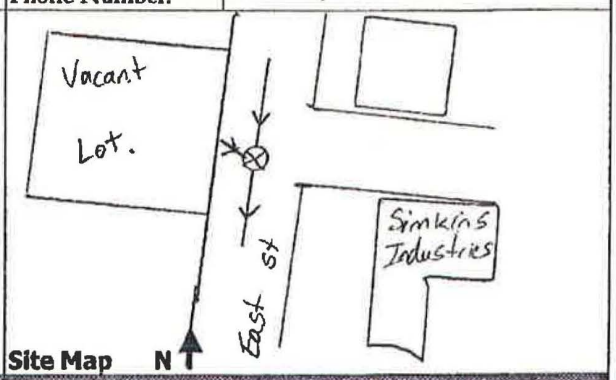
ADS ENVIRONMENTAL SERVICES

ADS Site Report — Quality Form

Project Name: New Haven TFM				City/State: New Haven, CT		FM Initials: GE	
Site Name: CSO-026	Monitor Series: 3500			Monitor S/N:	5753.		
Address / Location: At 293 East St. Outside Simkins Industries entrance.				Manhole #:			
				Map Page #:			
Access: Drive.	Type of System:	Sanitary ☐	Storm ☐	Combined ☒	Pipe Height:	53.25"	
					Pipe Width:	56.50.	
					Phone Number:		



Access Map



Site Map

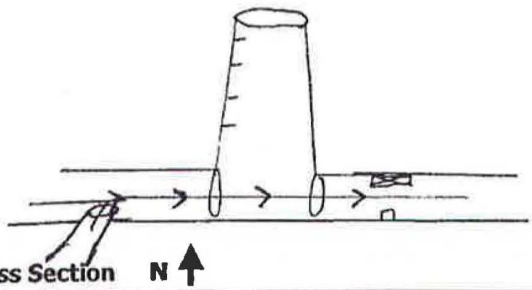
Investigation Information:

Date/ Time of Investigation:	4/11/07	15:00.	
Site Hydraulics:	Fast, deep, flow		
Upstream Input: (I/S, P/S)	NA		
Upstream Manhole:	DNI		
Downstream Manhole:	DNI		
Depth of Flow (Wet Dof):	22-50	+/-	
Range (Air Dof):		+/-	
Peak Velocity:	2-70	fps	
Silt:	0-5	Inches	

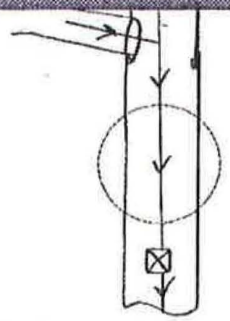
Manhole Information:

Manhole Depth:	15	Feet			
Manhole Material / Condition:	Brick / Fair				
Pipe Material / Condition:	Brick - Fair				
Mini System Character:	Residential ☐	Commercial ☒	Industrial ☒	Other	
Telephone Information:	—				
Access Pole #:	—				
Distance From Manhole:	—	Feet			
Road Cut Length:	—	Feet			
Trench Length:	—	Feet			

Other Information



Cross Section



Planar

Installation Information	
Installation Type:	Special Install
Sensors/Devices:	Uttra, Vel + Press
Surcharge Height:	8' Feet
Rain Gauge Zone:	

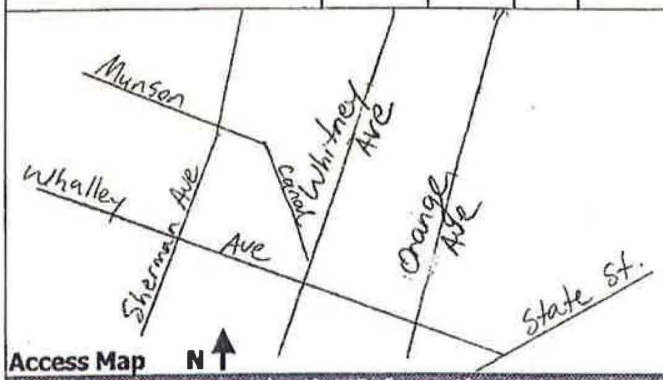
Backup	Yes	No	?	Distance
Trunk	☐	☒		
Lift/Pump Station	☐	☒		
WWTP	☐	☒		
Other	☐	☒		

Additional Site Information/Comments:

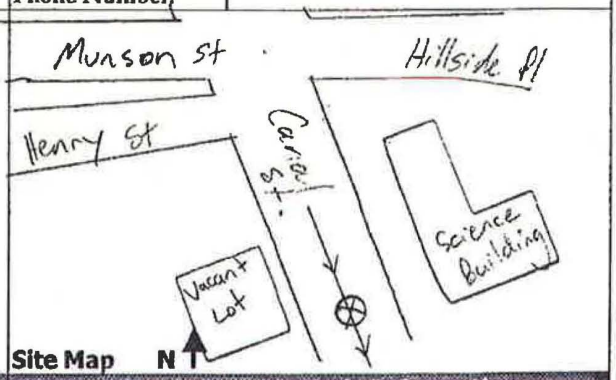
ADS ENVIRONMENTAL SERVICES

ADS Site Report — Quality Form

Project Name: New Haven TFM				City/State: New Haven, CT		FM Initials: GE
Site Name: Canal	Monitor Series: 3500			Monitor S/N:	6386.	
Address / Location: Canal St. South of Munson St.				Manhole #:		
				Map Page #:		
Access: Drive.	Type of System:	Sanitary ☐	Storm ☐	Combined ☒	Pipe Height:	54.00
					Pipe Width:	56.50
					Phone Number:	



Access Map N



Site Map N

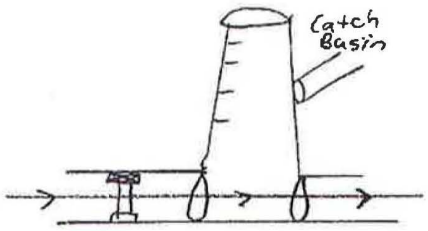
Investigation Information:

Date/ Time of Investigation:	4/11/07				
Site Hydraulics:	Fast, Choppy flow.				
Upstream Input: (L/S, P/S)	NA				
Upstream Manhole:	DNI				
Downstream Manhole:	DNI				
Depth of Flow (Wet Dof):	6.00	+/-			
Range (Air Dof):	48.00	+/-			
Peak Velocity:	3.20	fps			
Silt:	0	Inches			

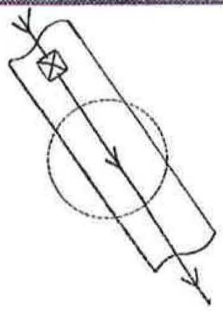
Manhole Information:

Manhole Depth:	15	Feet			
Manhole Material / Condition:	Brick / Fair				
Pipe Material / Condition:	Brick - Fair				
Mini System Character:	Residential ☒	Commercial ☐	Industrial ☐	Other	
Telephone Information:	—				
Access Pole #:	—				
Distance From Manhole:	—	Feet			
Road Cut Length:	—	Feet			
Trench Length:	—	Feet			

Other Information



Cross Section N



Planar N

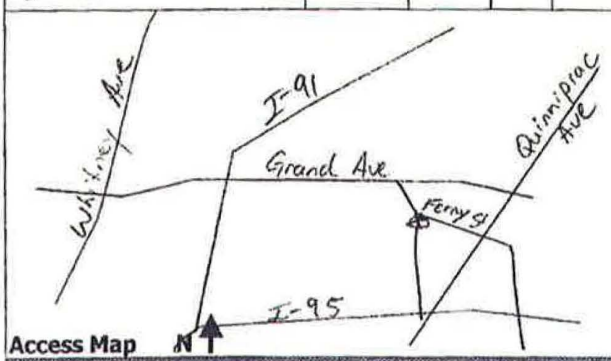
Installation Information		Backup	Yes	No	?	Distance
Installation Type:	Ring + Crank	Trunk	☐	☒		
Sensors/Devices:	Ultra, Vel + Press.	Lift/Pump Station	☐	☒		
Surcharge Height:	Feet	WWTP	☐	☒		
Rain Gauge Zone:		Other	☐	☒		

Additional Site Information/Comments:

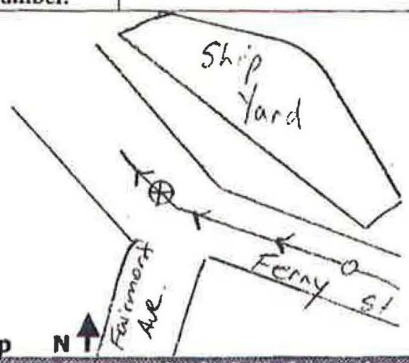
ADS ENVIRONMENTAL SERVICES

ADS Site Report — Quality Form

Project Name: New Haven TFM		City/State: New Haven, CT		FM Initials: GC.	
Site Name: Ferry	Monitor Series: 3500		Monitor S/N:	6100	
Address / Location: Ferry St at Fairmont Ave. Driveway to Shipyard			Manhole #:		
			Map Page #:		
Access: Drive	Type of System:	Sanitary ☐ Storm ☐ Combined ☒	Pipe Height:	24-00"	
			Pipe Width:	24-13"	
			Phone Number:		



Access Map



Site Map

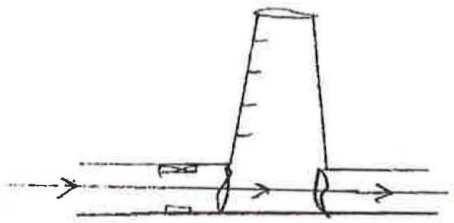
Investigation Information:

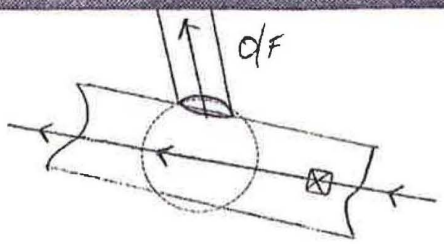
Date/ Time of Investigation:	4/11/07
Site Hydraulics:	Deep, Smooth flow.
Upstream Input: (L/S, P/S)	NA
Upstream Manhole:	Bad Hydraulics
Downstream Manhole:	DNI
Depth of Flow (Wet Dof):	15.50. +/-
Range (Air Dof):	8.50 +/-
Peak Velocity:	2.10 fps
Silt:	0 Inches

Manhole Information:

Manhole Depth:	9'	Feet			
Manhole Material / Condition:	Brick / Fair				
Pipe Material / Condition:	RCP	Fair			
Mini System Character:	Residential ☒	Commercial ☒	Industrial ☐	Other	
Telephone Information:	—				
Access Pole #:	—				
Distance From Manhole:	—	Feet			
Road Cut Length:	—	Feet			
Trench Length:	—	Feet			

Other Information


Cross Section N



Planar N

Installation Information		Backup	Yes	No	?	Distance
Installation Type:	King + Crank	Trunk	☐	☒		
Sensors/Devices:	Ultra, Vel + Press.	Lift/Pump Station	☐	☒		
Surcharge Height:	6 Feet	WWTP	☐	☒		
Rain Gauge Zone:	RG-3	Other	☐	☒		

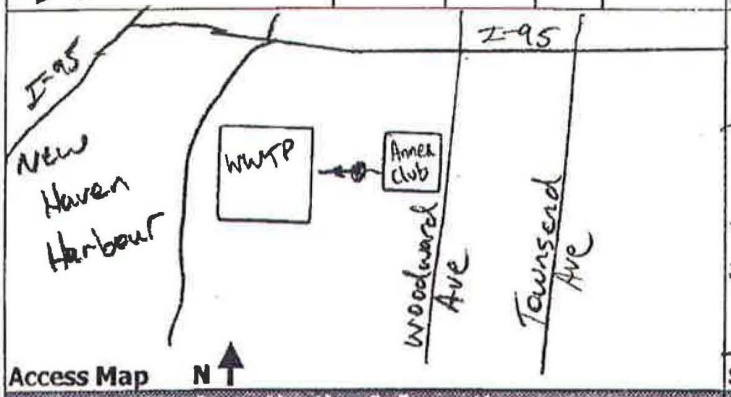
Additional Site Information / Comments:

GNH0016-115

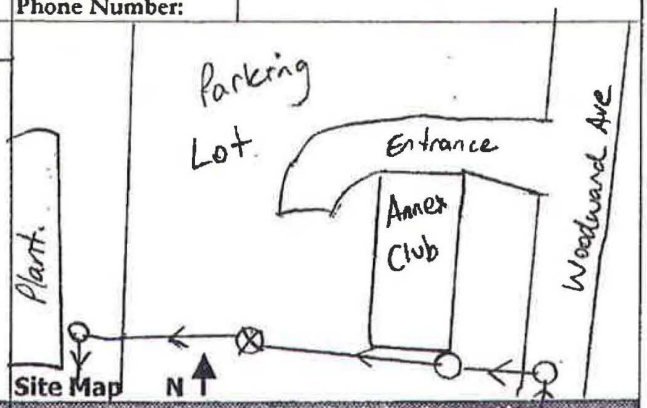
ADS ENVIRONMENTAL SERVICES

ADS Site Report — Quality Form

Project Name: New Haven TFM	City/State: New Haven CT				FM Initials:	
Site Name: Woodward	Monitor Series: 3500				Monitor S/N:	6407
Address / Location: In Parking Lot of Annex Club off Woodward Ave.					Manhole #:	
					Map Page #:	
Access: Drive	Type of System:	Sanitary ☒	Storm ☐	Combined ☐	Pipe Height:	42.00"
					Pipe Width:	42.00"
					Phone Number:	



Access Map N



Site Map N

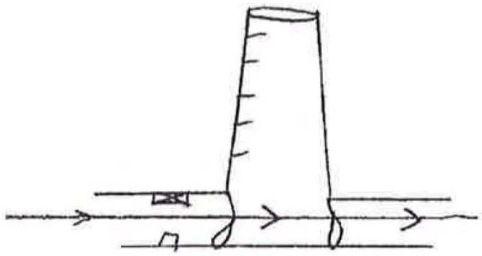
Investigation Information

Date/ Time of Investigation:	4/11/07
Site Hydraulics:	Very fast, jumpy flow
Upstream Input: (L/S, P/S)	NA
Upstream Manhole:	Bad Hydraulics
Downstream Manhole:	Bad Hydraulics
Depth of Flow (Wet Dof):	5.00 +/-
Range (Air Dof):	+/-
Peak Velocity:	12.00 fps
Silt:	0 Inches

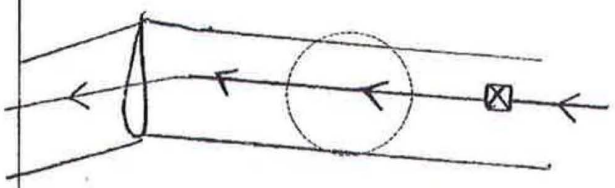
Manhole Information

Manhole Depth: 13 Feet				
Manhole Material / Condition: Concrete / Fair				
Pipe Material / Condition: RCP / Fair				
Mini System Character:	Residential ☒	Commercial ☒	Industrial ☐	Other
Telephone Information: —				
Access Pole #: —				
Distance From Manhole: — Feet				
Road Cut Length: — Feet				
Trench Length: — Feet				

Other Information



Cross Section N



Planar N

Installation Information	
Installation Type:	Ring + Crank
Sensors/Devices:	Ultra, Vel + Press
Surcharge Height:	NO Feet
Rain Gauge Zone:	RG-1

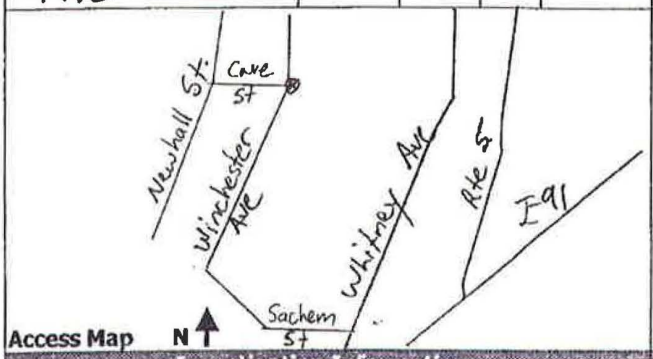
Backup	Yes	No	?	Distance
Trunk	☐	☒		
Lift/Pump Station	☐	☒		
WWTP	☐	☒		
Other	☐	☒		

Additional Site Information/Comments:

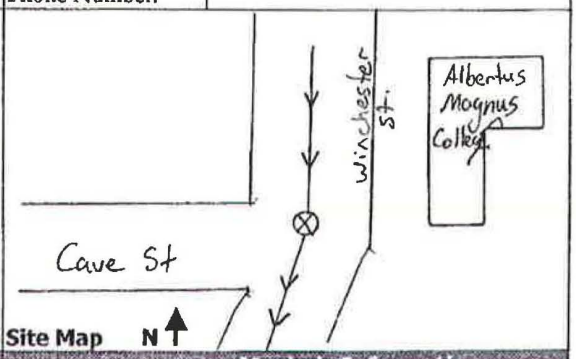
ADS ENVIRONMENTAL SERVICES

ADS Site Report — Quality Form

Project Name: New Haven TFM			City/State: New Haven, CT		FM Initials: GE	
Site Name: NH-04	Monitor Series: 3500			Monitor S/N:	4693	
Address / Location: At the intersection of Winchester + Cave Sts				Manhole #:		
				Map Page #:		
Access: Drive	Type of System:	Sanitary ☒	Storm ☐	Combined ☐	Pipe Height:	24-25"
					Pipe Width:	24-25"
					Phone Number:	



Access Map N



Site Map N

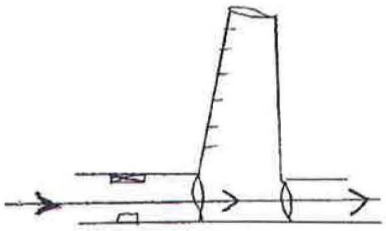
Investigation Information

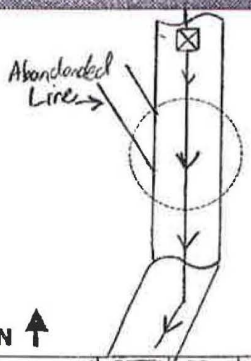
Date/ Time of Investigation:	4/11/07
Site Hydraulics:	Good, Moderate flow.
Upstream Input: (L/S, P/S)	NA
Upstream Manhole:	DNI
Downstream Manhole:	DNI
Depth of Flow (Wet Dof):	8.50 +/-
Range (Air Dof):	26.00 +/-
Peak Velocity:	2.00 fps
Silt:	0 Inches

Manhole Information

Manhole Depth:	11 Feet				
Manhole Material / Condition:	Brick Fair				
Pipe Material / Condition:	VCP Fair				
Mini System Character:	Residential ☒	Commercial ☐	Industrial ☐	Other	
Telephone Information:	—				
Access Pole #:	—				
Distance From Manhole:	— Feet				
Road Cut Length:	— Feet				
Trench Length:	— Feet				

Other Information


Cross Section N



Planar N

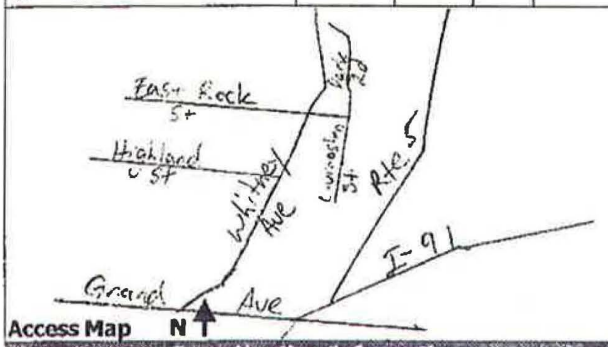
Installation Information		Backup	Yes	No	?	Distance
Installation Type:	Ring + Crank	Trunk	☐	☒		
Sensors/Devices:	Ultra, Vel + Press	Lift/Pump Station	☐	☒		
Surcharge Height:	N/O Feet	WWTP	☐	☒		
Rain Gauge Zone:	RG-2	Other	☐	☒		

Additional Site Information/Comments:

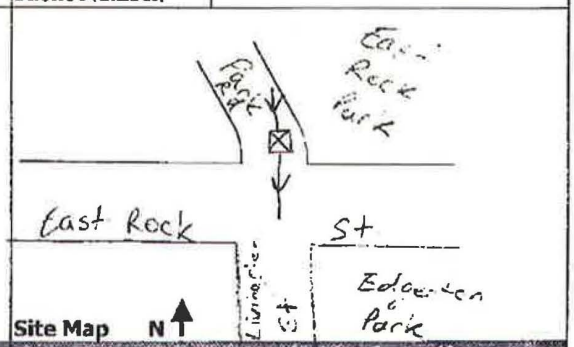
ADS ENVIRONMENTAL SERVICES

ADS Site Report — Quality Form

Project Name: New Haven TFM				City/State: New Haven, CT		FM Initials: GE	
Site Name: NH-11	Monitor Series: 3500			Monitor S/N:	6406		
Address / Location: At Intersection of East Rock St + Park Rd				Manhole #:			
				Map Page #:			
Access: Drive	Type of System:	Sanitary ☒	Storm ☐	Combined ☐	Pipe Height:	36.00"	
					Pipe Width:	37.25"	
					Phone Number:		



Access Map



Site Map

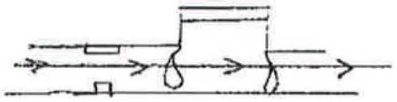
Investigation Information:

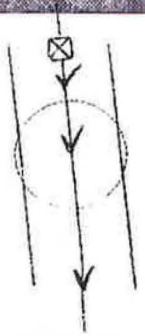
Date/ Time of Investigation:	4/11/07
Site Hydraulics:	Deep, Moderate f cw.
Upstream Input: (L/S, P/S)	NP
Upstream Manhole:	DNI
Downstream Manhole:	DNI
Depth of Flow (Wet Dof):	+/-
Range (Air Dof):	+/-
Peak Velocity:	fps
Silt:	Inches

Manhole Information:

Manhole Depth:	3	Feet			
Manhole Material / Condition:	Concrete / Poor				
Pipe Material / Condition:	Concrete / Poor				
Mini System Character:	Residential ☒	Commercial ☐	Industrial ☐	Other	
Telephone Information:					
Access Pole #:					
Distance From Manhole:	—	Feet			
Road Cut Length:	—	Feet			
Trench Length:	—	Feet			

Other Information


Cross Section N


Planar N

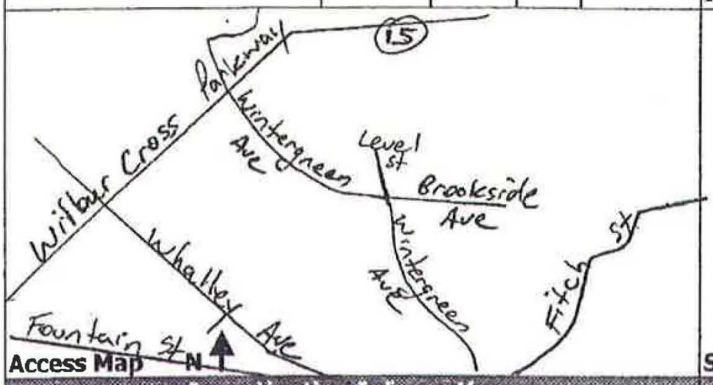
Installation Information		Backup	Yes	No	?	Distance
Installation Type:	Ring + Crank	Trunk	☐	☒		
Sensors/Devices:	Sludge, Vel + Press	Lift/Pump Station	☐	☒		
Surcharge Height:	3 Feet	WWTP	☐	☒		
Rain Gauge Zone:	RG-3	Other	☐	☒		

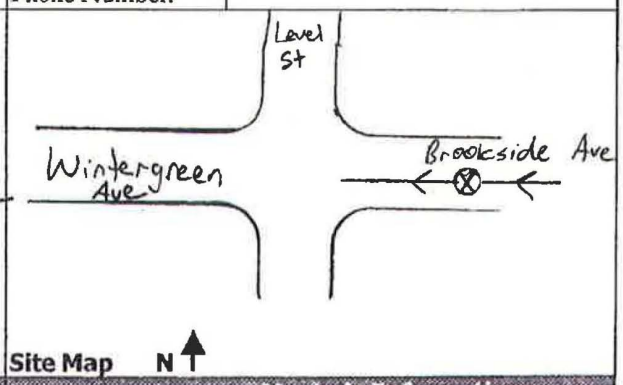
Additional Site Information/Comments:

ADS ENVIRONMENTAL SERVICES®

ADS Site Report — Quality Form

Project Name: New Haven TFM			City/State: New Haven CT		FM Initials: GE	
Site Name: Brookside	Monitor Series: 3500		Monitor S/N: 5345			
Address / Location: Brookside Ave East of Wintergreen Ave.			Manhole #:			
			Map Page #:			
Access: Drive	Type of System:	Sanitary ☒	Storm ☐	Combined ☐	Pipe Height: 29.88"	
					Pipe Width: 30-50"	
					Phone Number:	





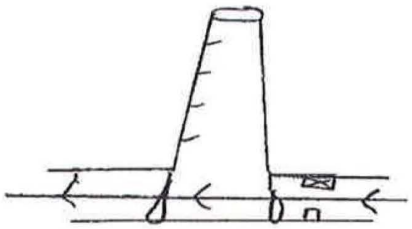
Investigation Information:

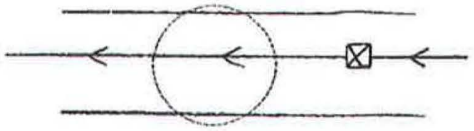
Date/ Time of Investigation:	4/10/07
Site Hydraulics:	Deep, Slow, flow. Small surge.
Upstream Input: (L/S, P/S)	NA
Upstream Manhole:	DNE
Downstream Manhole:	DNE
Depth of Flow (Wet Dof):	+/-
Range (Air Dof):	+/-
Peak Velocity:	fps
Silt:	Inches

Manhole Information:

Manhole Depth:	12	Feet			
Manhole Material / Condition:					
Pipe Material / Condition:					
Mini System Character:	Residential ☒	Commercial ☐	Industrial ☐	Other	
Telephone Information:	—				
Access Pole #:	—				
Distance From Manhole:	—	Feet			
Road Cut Length:	—	Feet			
Trench Length:	—	Feet			

Other Information





Installation Information		Backup	Yes	No	?	Distance
Installation Type:	Rigi+Crank	Trunk	☐	☒		
Sensors/Devices:	Ultra, Vel + Press.	Lift/Pump Station	☐	☒		
Surcharge Height:	Feet	WWTP	☐	☒		
Rain Gauge Zone:	RG-2	Other	☐	☒		

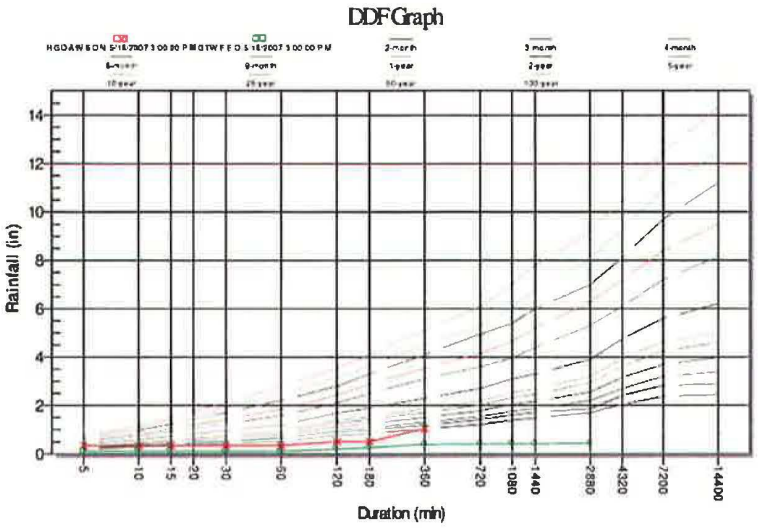
Additional Site Information/Comments:

Attachment 2

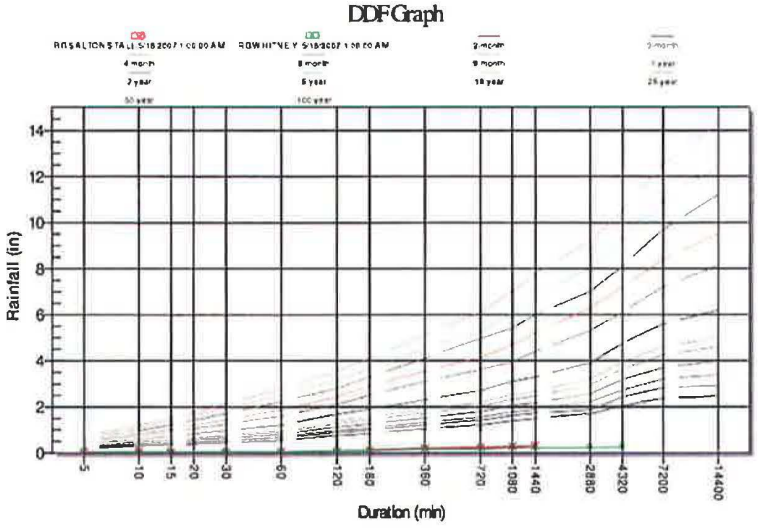
Compound Rainfall Hyetograph of Monitoring Period

Rainfall Depth Duration Frequency Curves

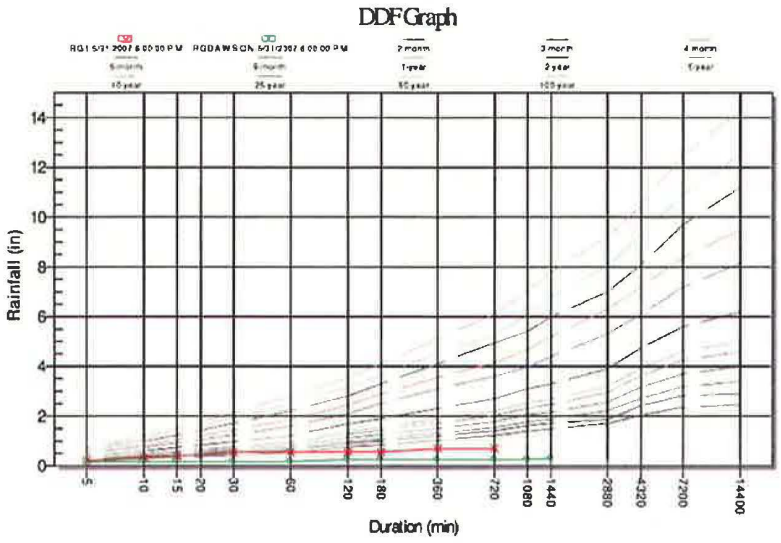
May 16, 2007 Event – Less than or equal to a 2-month storm



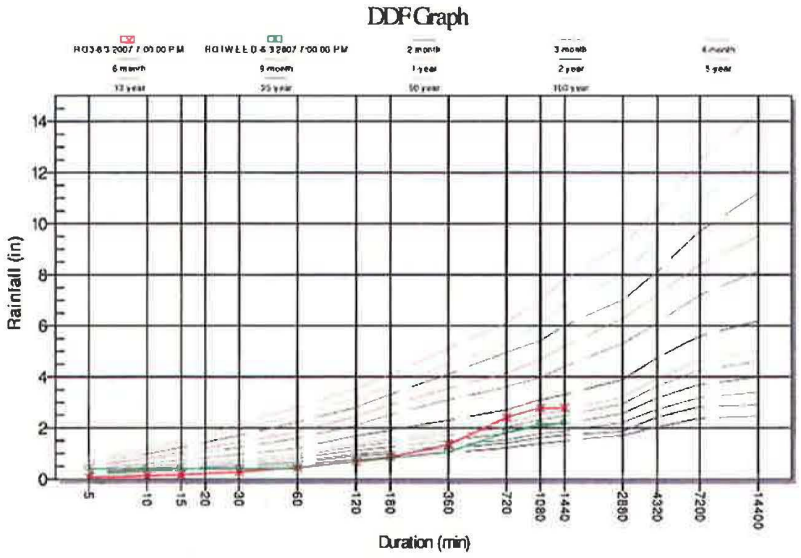
May 18, 2007 Event – Less than a 2-month return period



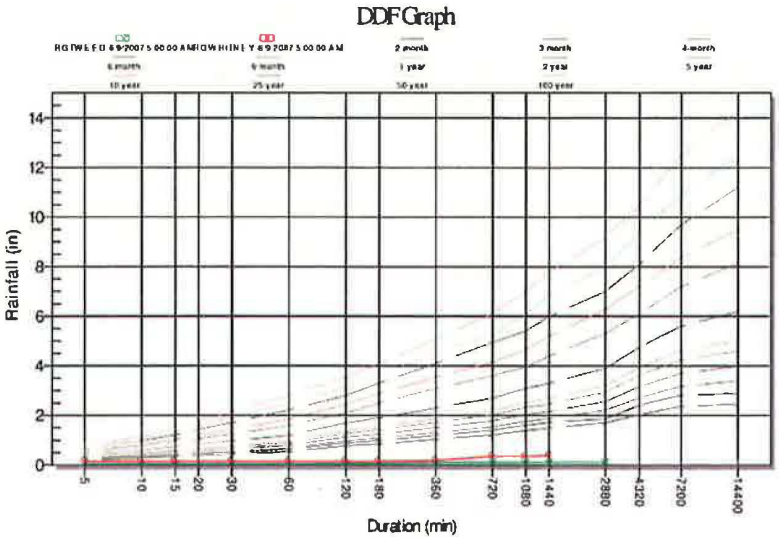
May 31, 2007 Event – Less than a 2-month return period.



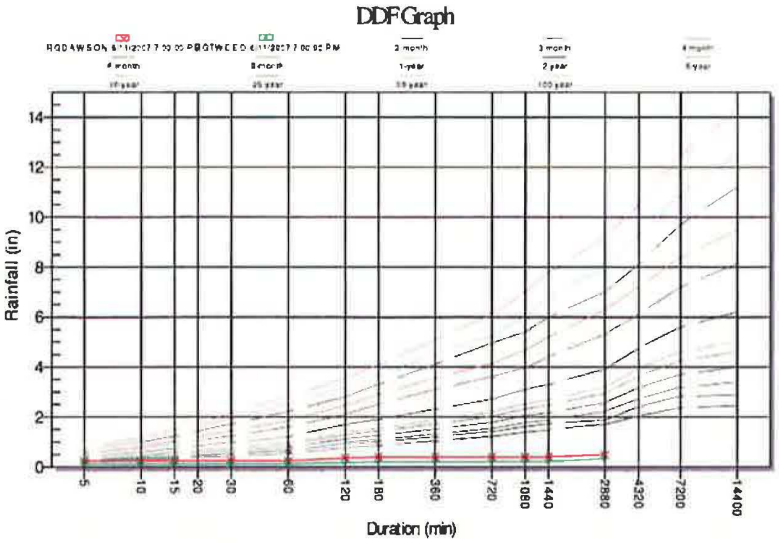
June 3, 2007 Event – Between a 6-month and a 2-year return period



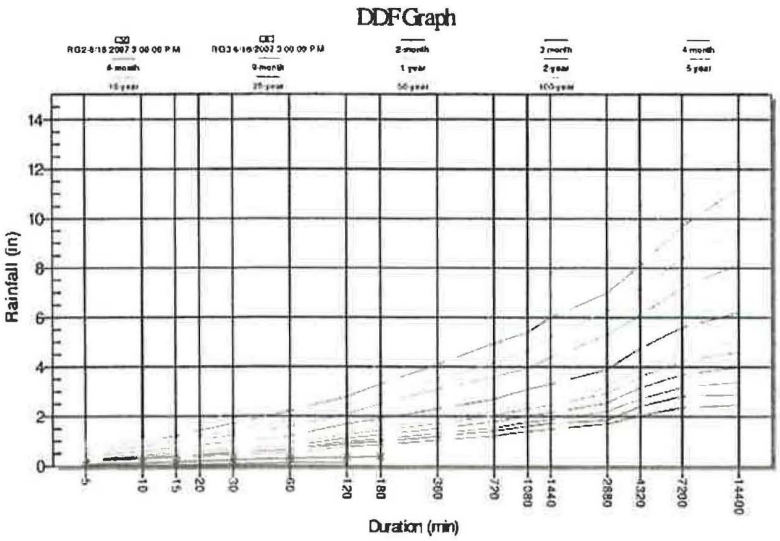
June 9, 2007 Event – Less than a 2-month return period.



June 11, 2007 Event – Less than a 2-month return period.



June 16, 2007 Event – Less than a 2-month return period



Greater New Haven Water Pollution Control Authority

Wet Weather Capacity Improvements – Hydraulic Model Update

Model Performance Verification

PREPARED FOR: GNHWPCA

PREPARED BY: CH2M HILL

DATE: September 13, 2007

PROJECT NUMBER: 350590

Introduction

During recent modeling activities to support Preliminary Engineering for Wet Weather Capacity Improvements, it was found that the planning-level hydraulic modeling scenarios previously developed to support the Greater New Haven Water Pollution Control Authority ("the Authority") Long-term Control Plan (LTCP) no longer reflects the collection system as it exists today. In the time since development of the LTCP model in 1997, several changes have occurred in the New Haven collection system, such as sewer separation projects, regulator modifications, and conventional growth and development. The Authority is conducting a Hydraulic Model Update task to update the model, verify that it accurately represents existing conditions, and to have a more current tool for evaluating engineering alternatives for its Wet Weather Preliminary Engineering project.

Several model update efforts are now completed. The Authority's hydraulic model was updated to reflect 2007 existing conditions in the collection system, as described in the August 1, 2007 *Hydraulic Model Improvements* technical memorandum. A monitoring program was conducted in May and June 2007 and documented in the *Short-Term Flow Monitoring Program* technical memorandum, dated August 16, 2007.

This technical memorandum summarizes the model performance verification that was performed following the Short-term Flow Monitoring Program, which includes documentation on how the model was evaluated and adjusted to accurately simulate existing conditions. The memorandum also includes an evaluation of currently available data and provides recommendations for future monitoring of the system to fill in missing data gaps and further improve the accuracy of the model for future planning and design needed to implement the Authority's LTCP.

Verification Methodology and Execution

The model evaluation methodology consisted of three main components:

- Rainfall Event Selection - Compile and analyze flow and rainfall data collected during Task 3 Short-term Flow Monitoring Program and select one dry and three wet weather events for model evaluation;
- Model Assessment - Assess the accuracy of the updated hydraulic model in predicting current system operating conditions in response to the selected rainfall events; and,
- Model Verification - Debug and verify that the hydraulic model simulates collection system responses to dry and wet weather events with reasonable results.

Flow and rainfall data collected during the execution of Task 3 Short-term Flow Monitoring Program, described in the August 16, 2007 *Short-Term Flow Monitoring Program* technical memorandum, was compiled with other system data. Flow monitoring was performed at 24 locations in the collection system, and rainfall data was collected at three locations. Additional system data that was obtained included hourly flow data at the East Shore Water Pollution Abatement Facility (WPAF) and the East Street, Boulevard, East Shore, Barnes, Quinnipiac and Morris Cove Pump Stations. Additional rainfall data was obtained from the National Climatic Data Center for Tweed Airport and from the Regional Water Authority (RWA) at three of their stations (Whitney, Furnace Pond, and Dawson).

A rainfall analysis described in the August 16, 2007 Short-Term Flow Monitoring Program technical memorandum identified a number of wet weather events as candidates for model evaluation simulations. One dry weather period and three wet weather events were selected for verification modeling.

Model simulations were then compared to data to assess the accuracy of the updated hydraulic model database in predicting current system operating conditions. The assessment identified that additional changes in the model were required to simulate the system with reasonable results. Some of these changes were recommend in the in the August 1, 2007 *Hydraulic Model Improvements* technical memorandum, such as model settings for pump station on/off controls that needed further adjustment beyond that initially specified during the model update to better reflect system operations.

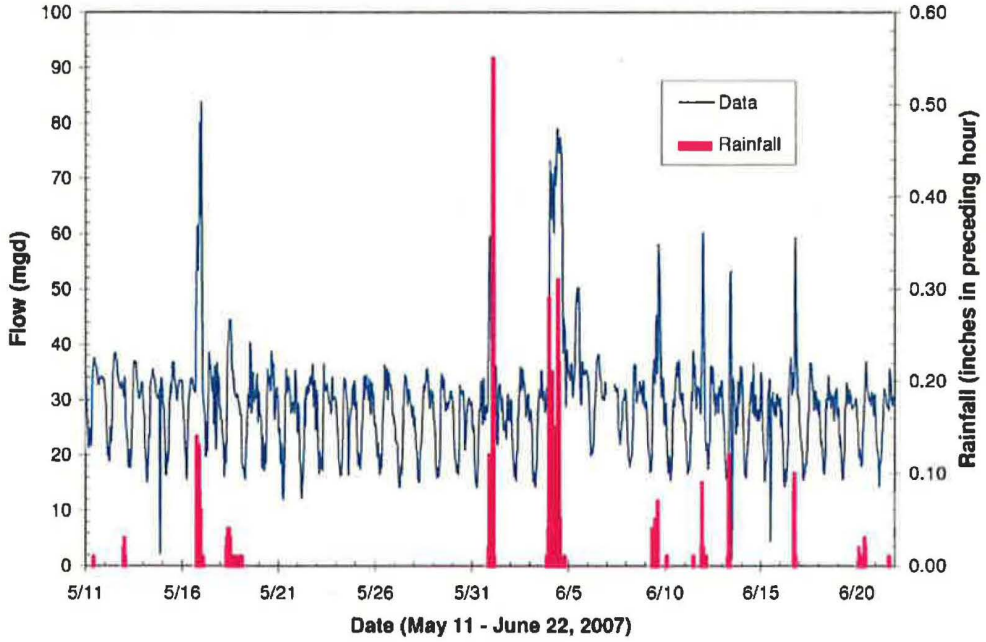
Quality Assurance/Quality Control (QA/QC) checks were then performed to debug remaining model construction issues and verify that the hydraulic model is sufficient for performing dry and wet weather simulations for existing conditions.

The following describes the selection of rainfall events, dry and wet weather verifications, model assessment, additional modifications made to the model for QA/QC, and conclusions and recommendations.

Rainfall Event Selection

The short-term flow-monitoring program was conducted between May 11 and June 22, 2007. Exhibit 1 illustrates East Shore WPAF flow data with rainfall data during the monitoring period.

EXHIBIT 1
East Shore WPAF Flow with Rainfall Recorded During the May 11 to June 22 Short-term Flow Monitoring Program



Dry Weather Period Selection

The dry weather period was selected by analyzing the rainfall record of the short-term monitoring program and identifying a period of seven days without precipitation. A period of dry weather occurred between May 18 and 30, 2007. The East Shore WPAF flow averaged 27.0 million gallons per day (mgd) during this period. Selecting days towards the end of this period would have been ideal for the dry weather verification to eliminate any latent effects of a preceding wet weather event. However, Memorial Day weekend was May 26-28. WPAF data approaching the weekend appeared to show decreasing flows and changing diurnal patterns. Following the weekend the data appeared to show recovering flow characteristics approaching typical conditions, but then a rain event occurred.

Two days were selected from this period to verify dry weather flow calculations – May 21 and 22. This period began only three days following a wet weather event on May 18, which had a total of 0.23 to 0.32 inches of rainfall recorded between several gages. Collection system and WPAF flow data indicated that there were no residual effects of the wet weather event by May 21. Average WPAF flow during the two days was 27.2 mgd; comparing well to the entire May 18-30 dry period. The original LTCP modeling effort calibrated the hydraulic model with an average dry weather flow of about 30 mgd. Dry weather flow recorded at the WPAF varied from a minimum of 15-20 mgd to a maximum of 30-35 mgd during the entire short-term monitoring program. WPAF flow ranged from 12 mgd to 36

mgd during the two days. The LTCP calibration ranged from 14 mgd to 40 mgd during dry weather.

Wet Weather Period Selection

Seven wet weather events of significance occurred during the short-term monitoring program. A goal of the verification was to identify and simulate three wet weather events of varying lengths, intensities, and volumes, with at least one event having characteristics of a 2-year recurrence interval similar to that used in developing the LTCP. An inter-event period of 12 hours was also applied to distinguish between events.

Three events were selected for the wet weather verification: May 16, May 31, and June 3, 2007. The recorded rainfall, peak intensity, approximate duration, peak recorded WPAF flow, and return period of each of these events are summarized in Exhibit 2. Rainfall data was compiled from the three short-term monitoring program gages, Tweed Airport, and three RWA gages. Therefore, ranges of rainfall are presented in the table. Although the short-term monitoring program monitored rainfall at a much shorter interval, an hourly peak intensity statistic is tabulated in order to include the data from Tweed Airport and the RWA.

EXHIBIT 2
Event Statistics and Return Periods for the Three Wet Weather Verification Events

Event	Rainfall (inches)[1]	Peak Intensity (inches/hour) for 60-minute time step	Approximate Duration (hours)	Peak Recorded WPAF Flow (mgd)	Return Period[2]
1 May 16, 2007	0.42 to 0.88	0.38	8	84	≤ 2 months
2 May 31, 2007	0.28 to 0.71	0.55	7	60	< 2 months
3 June 3-4, 2007	2.17 to 2.78	0.65	22	79	Between 6 months and 2 years

1. Rainfall statistics taken from all rainfall data developed during the short-term monitoring program of May 11 through June 22, 2007 at seven locations.

2. Return period calculated using rainfall depth-duration-frequency data curves shown in the August 16, 2007 *Short-Term Flow Monitoring Program* technical memorandum.

Only one wet weather event during the short-term monitoring program, June 3, had a total rain depth within the LTCP 2-year design storm range. The total depth of this storm ranging from 2.17 to 2.78 inches amongst the rain gages is close to the LTCP 2-year design storm of 2.05 inches in total volume. None of the three storms had peak intensities as extreme as the LTCP 2-year design storm, which was 2.15 inches per hour occurring for 15 minutes. The May 31 event had a peak 15-minute intensity of 1.48 inches per hour recorded at Boulevard Pump Station (RG-1) although with smaller intensities at other gages at the same time. The next highest 15-minute intensity was 0.68 inches per hour recorded during several events at several gages. Peak WPAF flow recorded during two of the events was close to the WPAF design capacity of 100 mgd.

Model Performance Verifications

Model performance was evaluated by comparing model calculations to flow monitoring data collected in the collection system and at the East Shore WPAF during the short-term monitoring program. The 2007 Existing Conditions Model, described in the August 1, 2007 *Hydraulic Model Improvements* technical memorandum, was used for the evaluation and verification. The verification methodology was to review model performance system wide by reviewing model comparisons for the East Shore WPAF, at pump stations, and at short-term monitoring program locations. Model calculations of hydraulic depth were reviewed and flow was compared to data for the one dry weather and three wet weather verification events.

The meter locations and model nodes where hydraulic model calculations were compared to meter data are tabulated in Exhibit 3.

EXHIBIT 3
Summary of Locations where Hydraulic Model Calculations are Compared to Meter Data

Meter Name	Meter Location	Model Node
CSO 002	E.T. Grasso and Lamberton (u/s of 002 Regulator)	M21R002
CSO 003	E.T. Grasso and Orange (u/s of 003 Regulator)	L19R003
CSO 004	E.T. Grasso and N. Frontage (d/s of 004 Regulator)	K16D010
CSO 005	E.T. Grasso and Irving (u/s of 005 Regulator)	K14N100
CSO 006	Whalley and Fitch (u/s of 006 Regulator	K10N250
CSO 009	James and Grand (u/s of 009 Regulator)	S15R009
CSO 010	East Street and I-91 (u/s of 010 Regulators)	R14R10A
CSO 012	Canner and Nicoll (u/s of 012 Regulator)	R12R012
CSO 013	East Rock and Everit (d/s of 013 Regulator)	R09N020
CSO 014	Trumbull and State (u/s of 014 Regulator)	P14N090
CSO 015	James and River (u/s of 015 Regulator)	S18R015
CSO 016	River and Poplar (u/s of 016 Regulator)	T17N180
CSO 017	Front and Grand	U14R19A
CSO 018	Lombard and Front (u/s of 018 Regulator)	U13R018
CSO 019	Front and Chatham	U13N350
CSO 021	East and Long Wharf (u/s of 021 Regulator)	R18N030
CSO 024	Sea and Water (u/s of 024 Regulator)	O23R024
East/Ives	East South of Grand (u/s of East/Ives Regulator)	R16N110
Canal	Canal and Munson	O12N330
Ferry	Ferry and Fairmont	T18N100
Woodward	Woodward (in Annex Club parking lot)	T23N110
NH-04	Winchester and Cave	P08N230

EXHIBIT 3
Summary of Locations where Hydraulic Model Calculations are Compared to Meter Data

Meter Name	Meter Location	Model Node
NH-11	Park and East Rock	R08I010
NH-12	Brookside and Wilmont	K06N010
Boulevard Pump Station[1]	Pump discharge	O23P010
East Street Pump Station[1]	Pump discharge	R19P010
Barnes Pump Station[1]	Pump discharge	W13P120
Quinnipiac Pump Station[1]	Pump discharge	W10P010
Morris Cove Pump Station[1]	Pump discharge	U31P010
East Shore WPAF[2]	Chlorine contact basin (plant effluent)	n/a

1. Using facility SCADA data.
2. SCADA data is only available at this location for the WPAF.

Dry Weather Flow Evaluation and Verification

Two days during the dry weather period were selected to verify dry weather flow calculations in the hydraulic model - May 21-22. Model dry weather flow and its diurnal curve were taken from the LTCP hydraulic model and used in the 2007 Existing Conditions Model, without adjustment.

The Root-Mean Square Error (RMSE) of flow was calculated for monitoring locations during the dry weather event to make comparisons. RMSE is an indicator of how well flow is calculated using the model compared to monitoring data. The RMSE is the average of the absolute differences between individual model calculations (c_i) and data observations (d_i) expressed as:

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(c_i - d_i)^2}$$

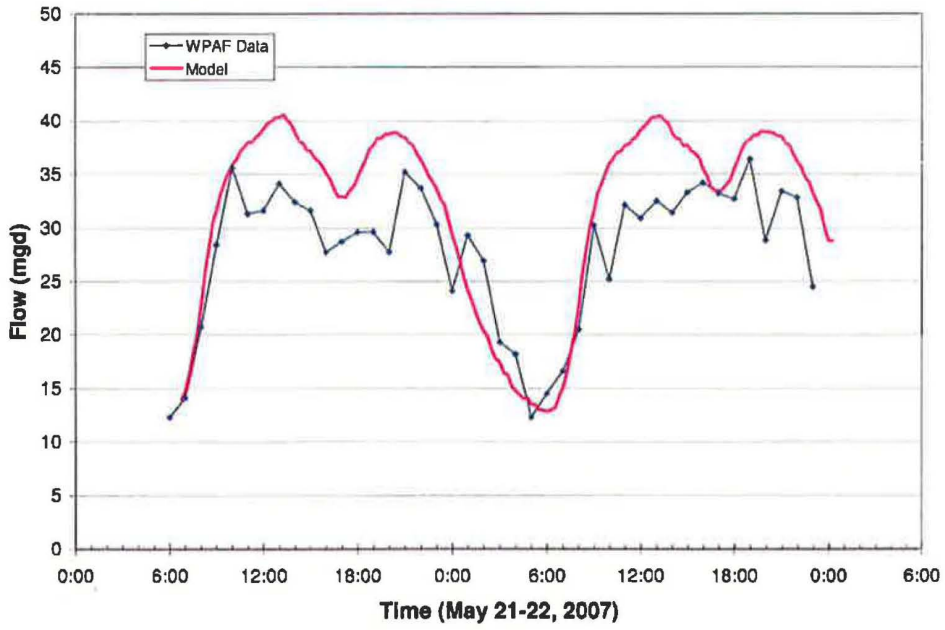
The model assessment and evaluation used an average difference and RMSE range of 1.0 mgd or 10 percent as a measure of model accuracy.

Exhibit 4 summarizes model comparisons to data for the pump stations and WPAF using flow statistics for the dry weather period. Exhibit 5 illustrates temporal model calculations compared to WPAF data for the dry weather period of May 21-22, 2007.

EXHIBIT 4
Calculated Dry Weather Flow Compared to Data for May 21-22, 2007 at Pump Stations and WPAF

	Flow (mgd)		Average Difference Model vs. Meter		
Meter	Meter	Model	Flow (mgd)	Flow (%)	RMSE
East Shore WPAF	26.8	29.9	+3.1	+12	5.3
Boulevard Pump Station	9.5	8.8	-0.8	-8	1.8
East Street Pump Station	11.9	11.3	-0.6	-5	6.4
Barnes Pump Station	1.1	0.5	-0.6	-58	1.5
Quinnipiac Pump Station	1.8	1.5	-0.3	-15	2.1
Morris Cove Pump Station	4.7	1.8	-2.9	-62	3.0

EXHIBIT 5
Calculated Dry Weather Flow Compared to Data at the East Shore WPAF



Overall, the model-specified diurnal patterns approximates data, however peak flows are over-calculated. System-wide, the calculated diurnal daily flow is 29.9 mgd using the hydraulic model compared to 26.8 mgd observed at the WPAF. The model calculation is 3.1 mgd higher than that observed, a 12% difference.

Dry weather verification comparisons for the pump stations are provided in Attachment 1. Comparisons for pump stations varied widely on a straight flow calculation basis as well as an RMSE. Model calculations for the pump stations vary in accuracy. Boulevard Pump Station flow is calculated relatively well compared to data. At the East Street Pump Station, average flow is calculated well compared to the average recorded; although the hourly flow calculations vary widely from the data. The SCADA data at his station, as well as the other stations appears erratic (such as instantaneous peaks and lows out of the pattern). If the data is accurate, the on/off controls at the pump station may require additional investigation and coordination with modeling. However, the meters at the pump stations may need to be checked for accuracy.

Sporadic and inconsistent facility data for the Barnes and Quinnipiac Pump Stations indicate that pump station controls and other factors appear to affect recorded flow during the period. Although on/off controls were compiled from those being used at the facilities, model representation of the controls should be investigated further. Comparisons for the Morris Cove Pump Station indicate that some adjustment in the dry weather flow should be considered for future modeling efforts in this tributary area.

Exhibit 6 summarizes model comparisons to data for the short-term monitoring program locations using flow statistics for the dry weather period.

EXHIBIT 6
Calculated Dry Weather Flow Compared to Data for May 21-22, 2007 at Short-term Flow Monitoring Program Locations

	Flow (mgd)		Average Difference		
Meter	Data	Model	Flow (mgd)	Flow (%)	RMSE
CSO 006	1.4	1.4	0.0	1%	0.4
CSO 005	5.3	5.0	0.3	5%	1.0
CSO 004	6.2	7.2	1.0	16%	1.7
CSO 003	7.5	7.2	0.2	3%	1.4
CSO 002	9.4	7.3	2.0	22%	2.4
CSO 024	8.6	8.5	0.1	1%	1.9
CSO 009	1.2	1.2	0.1	6%	0.3
CSO 010	3.1	4.5	1.4	44%	1.7
CSO 012	4.0	3.8	0.2	4%	0.7
CSO 013	0.2	0.2	0.0	13%	0.1
CSO 014	1.9	2.1	0.2	9%	0.5
CSO 015	2.1	2.7	0.6	29%	1.0
CSO 016	0.6	0.6	0.0	2%	0.2
CSO 018	0.2	0.3	0.1	70%	0.1
CSO 019	0.2	0.4	0.1	56%	0.1

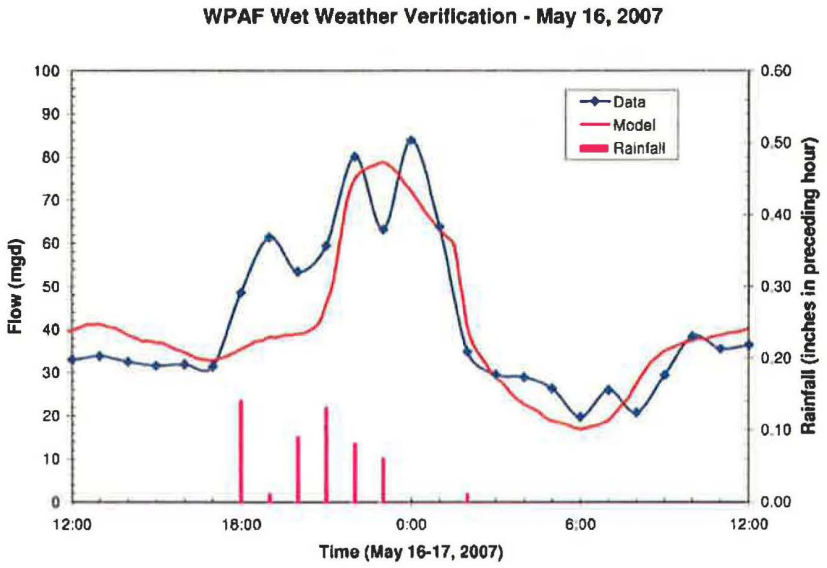
EXHIBIT 6
Calculated Dry Weather Flow Compared to Data for May 21-22, 2007 at Short-term Flow Monitoring Program Locations

	Flow (mgd)		Average Difference		
Meter	Data	Model	Flow (mgd)	Flow (%)	RMSE
CSO 021	8.4	11.3	2.9	34%	3.8
East Ives	5.7	7.2	1.5	27%	1.9
WLM	4.2	2.0	2.2	52%	2.2
Ferry	2.3	2.1	0.3	12%	0.5
Canal	0.6	1.4	0.8	126%	0.8
NH-04	0.6	0.6	0.0	3%	0.2
NH-11	3.4	3.2	0.2	7%	0.6
NH-12	1.7	2.4	0.7	43%	0.8
		Average:	0.6	25%	1.1

Model calculations compare relatively well to dry weather flow data collected during the Short-term Monitoring Program. Typically, model calibrations target calculations to be within 5% or 1 mgd of data. A majority of the average differences between calculations and data are less than 1 mgd, averaging 0.6 mgd overall. The average differences on a percent basis vary widely, some exceeding 100%; however, the higher differences occur at low-flow locations were there is a higher sensitivity to the differences on a percent basis. Overall, a majority of the RMSE was calculated less than 1.0 mgd, with an overall average of 1.1 mgd. Select dry weather verification comparisons for several monitoring locations are provided in Attachment 1.

Past data documented in LTCP technical memoranda (#3 and #7) indicate that historical WPAF dry weather flow varies between 29.5 mgd during dry seasons to 42.1 mgd during spring with full moon tides. Observed dry weather flow during this period exhibited differences compared to the LTCP effort in base flow and diurnal characteristics, and may be considered typical of current overall system performance. These differences may have been caused by changes made to the collection system since the LTCP effort including the Authority's sewer separation projects but also other infiltration/inflow-control efforts being made region wide. Dry weather flow is a small percentage of wet weather flow, especially during extreme events. The dry weather flow can be investigated further, but it would require a large effort compared to the small benefit to this model evaluation. In consideration of the small variability in base flow, the small percent difference between calculated and observed flow at the WPAF, and with limited time to perform a recalibration, the base sanitary flow specifications in the model were not modified to improve the dry weather flow calculation for this analysis.

EXHIBIT 8
Wet Weather Flow Verification at WPAF for May 16, 2007



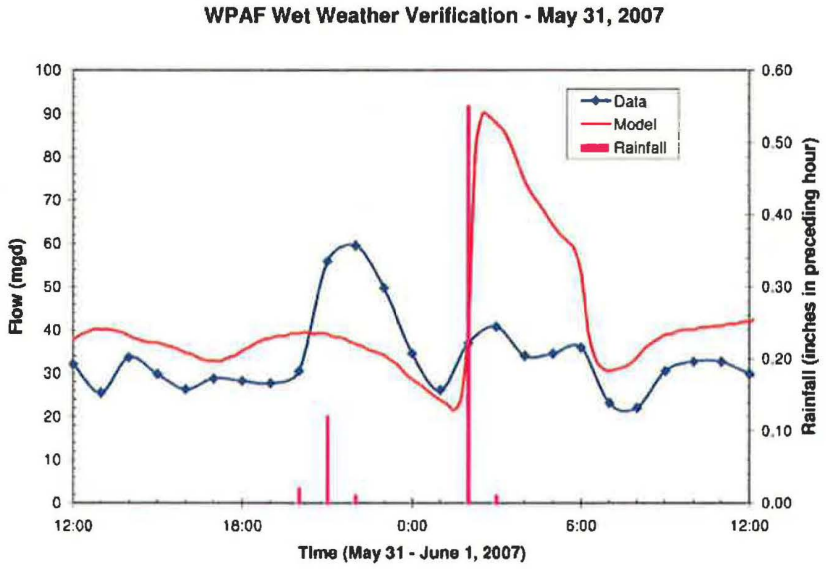
Overall, model calculations of flow at the WPAF compare relatively well to data. The timing of the event and response at the WPAF indicate that time-of-travel is simulated accurately between the collection system, force main conveyance, and the WPAF. The peak model calculated flow at the WPAF is 79 mgd occurring closely in time to the 84 mgd observed. Increasing flow at the beginning of the storm was not calculated compared to data. Rainfall was recorded at other rain gages an hour earlier than that used for modeling with the data at RG-1; some but not all gages recorded higher overall rainfall volumes. This difference can be attributed to local variations in the storm pattern amongst tributary areas. Model calculations of flow recovery back to the dry weather flow track closely with the data.

Model calculations compare relatively well to data at the pump stations and meters. Peak flows, timing, and recovery to dry weather flow track closely with the data. Similar to that seen in the WPAF data, increasing flow at the beginning of the storm was not calculated compared to data at many locations, which an be attributed to local variations in the storm pattern amongst tributary areas.

Event 2 - May 31, 2007

The rainfall recorded during the wet weather event on May 31, 2007 varied from 0.28 to 0.71 inches, over approximately seven hours with a peak 60-minute intensity of 0.55 inches/hour, which is a storm with less than a 2-month return period. The peak flow recorded at the East Shore WPAF was 60 mgd. Exhibit 9 presents flow calculations compared to data recorded at the WPAF for the event. Comparisons of model calculations to data for the pump stations and meters are provided in Attachment 2.

EXHIBIT 9
Wet Weather Flow Verification at WPAF for May 31, 2007



Model calculations varied from data at the WPAF and pump stations. The rainfall recorded at the RG-1 varied from other gages within the overall range of 0.28 to 0.71 between all seven gages. Although a peak rainfall was recorded early in the morning on June 1 at other locations, none were as high as that recorded at RG-1. Recorded total rainfall amounts during this event at the seven gages are as follows:

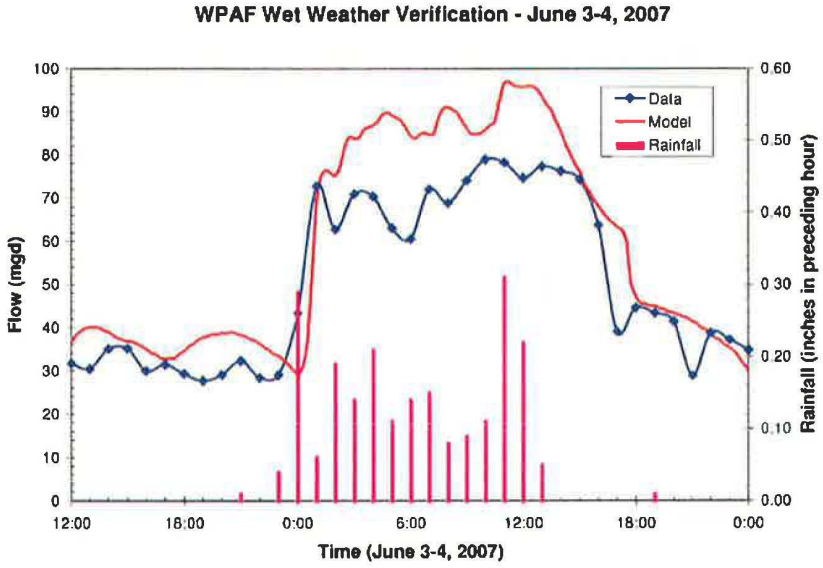
- Boulevard Pump Station (RG-1) - 0.71 inches
- Boulevard Pump Station (RG-2) – n/a
- Boulevard Pump Station (RG-3) - 0.33 inches
- Tweed Airport - 0.60 inches
- RWA Whitney - 0.28 inches
- RWA Furnace Pond - 0.32 inches
- RWA Dawson - 0.28 inches

The effects of these variations were observed in the data at the WPAF, pump stations, and meters. Initial increases in flow are calculated throughout the system but were not observed in the data. Later in the event, a peak was not experienced at the WPAF, although there was a noticeable increase in flow in the data for the Boulevard Pump Station, which corresponds with the data observed at RG-1. Overall, the conclusions that can be drawn from this event verification are that varying rainfall patterns within the service area have significant impact on system responses. Model simulations of events such as these should utilize more than one rainfall hyetograph to simulate localized patterns and more accurately calculate responses. A detailed rainfall analysis and additional simulations to improve model performance with this event would not be cost-effective for the purposes of this analysis.

Event 3 – June 3-4, 2007

The rainfall recorded during the wet weather event on June 3-4, 2007 varied from 2.17 to 2.78 inches, over approximately 22 hours with a peak 60-minute intensity of 0.65 inches/hour, which is a storm with a return period between six months and two years. The peak flow recorded at the East Shore WPAF was 79 mgd. This was the largest volume event of the three verification events, although the peak observed flow was smaller than that for the first event, which was 84 mgd. Exhibit 10 presents flow calculations compared to data recorded at the WPAF for the event. Comparisons of model calculations to data for the pump stations and select meters are provided in Attachment 2.

EXHIBIT 10
Wet Weather Flow Verification at WPAF for June 3-4, 2007



Overall, model calculations of flow at the WPAF compare relatively well to data, although peak flows are over-calculated. The timing of the event and response at the WPAF indicate that time-of-travel is simulated accurately between the collection system, force main conveyance, and the WPAF. However, the peak model-calculated flow at the WPAF is 97 mgd compared to the 79 mgd observed. This difference can also be attributed to local variations in the storm pattern amongst tributary areas; the rainfall recorded at RG-1 was actually less than other locations but peak intensities at RG-1 were higher than others except RG-3. Recorded total rainfall amounts during this event at the seven gages are as follows:

- Boulevard Pump Station (RG-1) - 2.21 inches
- Boulevard Pump Station (RG-2) – n/a
- Boulevard Pump Station (RG-3) – 2.78 inches
- Tweed Airport – 2.17 inches
- RWA Whitney – 2.28 inches

- RWA Furnace Pond – 2.25 inches
- RWA Dawson – 2.60 inches

Model calculations of flow recovery back to the dry weather flow track closely with the data.

Similar to that experienced for the WPAF, model calculations compare relatively well to data at the pump stations and meters, although peak flows are over-calculated at several locations while closely matching the data at others. The timing and recovery to dry weather flow track will with the data. The flow at Boulevard Pump Station is over-calculated while East Street Pump Station flows are under-calculated. These two pump stations share the same force main. The pumps at the Boulevard Pump Station are rpm-limited. This is accounted for in the hydraulic model, although an adjustment could be made in the model settings for this and other parameters to improve the accuracy of the flow calculation at a later time.

Conclusions and Recommendations

The purpose of the Model Performance Verification is to evaluate model performance to verify that the hydraulic model reflects current conditions when evaluating engineering alternatives for the Wet Weather Preliminary Engineering project. Flow and rainfall data were compiled from the Short-term Flow Monitoring program. A rainfall analysis was performed to identify one dry weather and three wet weather events that occurred during the recent flow-monitoring period to use for model performance evaluations. The Existing Conditions scenario of the New Haven collection system hydraulic model was used to simulate flow conditions during the four events. Model calculations were compared to data for evaluating and verifying model performance.

The hydraulic model simulates sewer separation, tank construction, regulator modifications, pump station improvements, and other Short-term and Long-term Control Plan actions the Authority implemented since LTCP development. An initial assessment of model calculations compared to data for the dry weather and three wet weather events showed that it was necessary to update the hydraulic model to reflect existing conditions before proceeding with wet weather preliminary engineering. Model parameters were somewhat adjusted to update and improve the accuracy of the model.

The model currently simulates dry weather characteristics reasonably well. Model performance in simulating the wet weather events varied in accuracy. The three wet weather events varied in size, duration, intensity, and pattern. System responses, peak flows, time of travel, and other event characteristics are calculated reasonably well when rainfall data is applied locally. Collection system capacity and conveyance is simulated well with the model. Flow monitoring and data collection at the WPAF and pump stations proved valuable for the analysis.

The model assessment and verification indicated that changes in the collection system have altered the way in which the system is reacting to wet weather events since the LTCP was developed. The Authority's hydraulic model has been updated to accurately simulate Existing Conditions, which can be used for preliminary engineering.

The following are observations and recommendations on rainfall and flow data collection for ongoing and future analyses:

- Rainfall is currently recorded at Tweed Airport and also monitored by the RWA at several locations in the service area. These data sources are sufficient for analyzing general rainfall patterns and characteristics, although only available on an hourly basis. Supplemental, local rainfall monitoring as that performed during the short-term monitoring program with shorter intervals should still be performed during future monitoring and modeling work.
- SCADA data is collected at the WPAF and pump stations, although it had to be compiled and transcribed for this analysis. Data recording should be automated at all locations to facilitate analysis with shorter recording intervals of 30 or 15 minutes.
- The Union Street Pump Station does not have automated data collection, although a metering program was performed preceding this analysis. SCADA monitoring and data compilation should be automated at this station as soon as possible and included in future pump station modifications.
- Pump station data appeared erratic during dry and wet weather periods. The meters should be checked to verify that they are accurately recording flow at low- and high-flow conditions and for on/off operation of the pumps.
- SCADA data for WPAF flow is only available from that recorded at the chlorine contact basin for effluent monitoring. Additional automated data collection should be installed for the WPAF influent and other locations in the process train for system and WPAF performance evaluations.
- Monitoring and modeling should be performed regularly following major collection system modifications to maintain model accuracy.

The hydraulic model has been updated to accurately represent existing conditions, and to have a more current tool. Model accuracy could be improved for future planning and design with additional actions as follows:

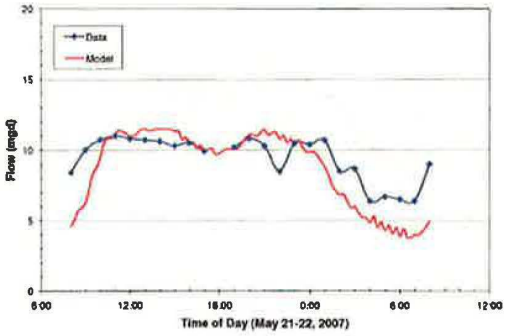
- Perform a detailed long-term analysis of dry weather flow throughout the system to improve dry weather flow calculations.
- Apply localized rainfall data amongst the tributary areas for improved runoff and system response calculations.
- Further analyze pump station performance parameters such as on/off controls and pumping performance at varying levels of dynamic head to refine flow calculations.
- Further analyze and refine model calculations for the Boulevard and East Street Pump Stations to better calculate flow in their shared force main.
- Further analyze flow data downstream of sewer separation projects to confirm runoff parameter modifications made to simulate the projects.

Attachment 1

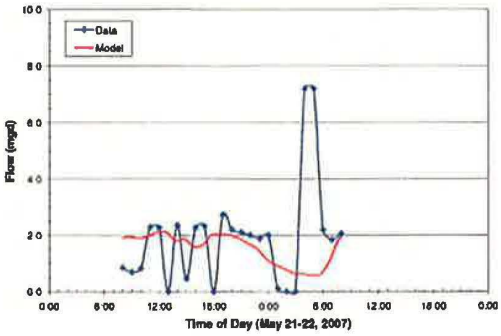
Dry Weather Flow Verifications

DRY WEATHER FLOW VERIFICATION
Pump Stations

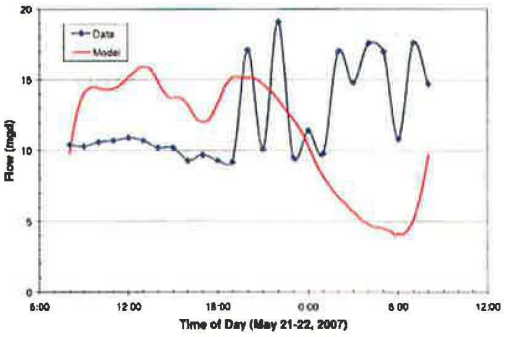
Boulevard Pump Station Dry Weather Verification



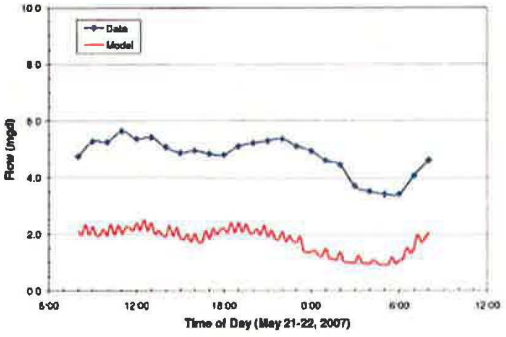
Quinnipiac Pump Station Dry Weather Verification



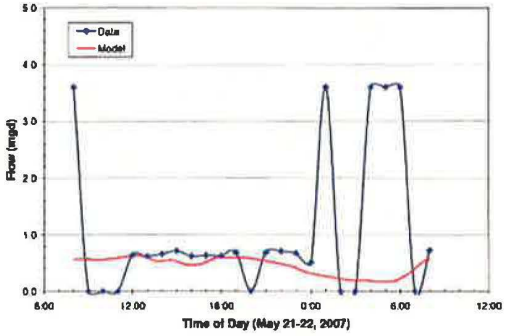
East Street Pump Station Dry Weather Verification



Morris Cove Pump Station Dry Weather Verification



Barnes Pump Station Dry Weather Verification

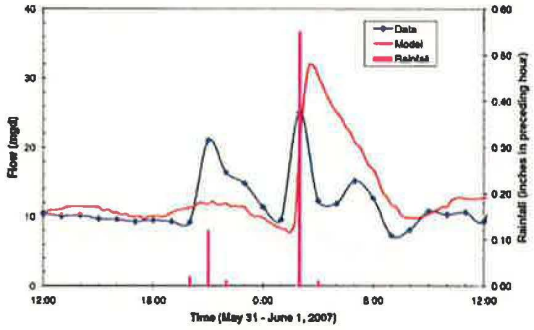


Attachment 2

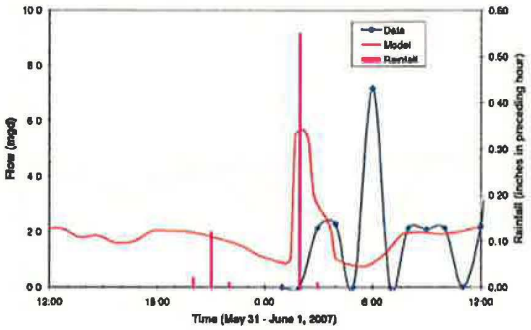
Wet Weather Flow Verifications

WET WEATHER FLOW VERIFICATION
Pump Stations – Event 2, May 31, 2007

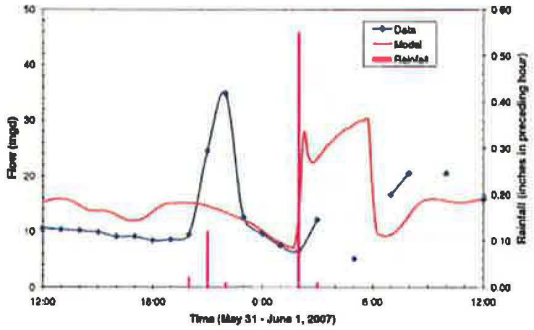
Boulevard Pump Station Wet Weather Verification - May 31, 2007



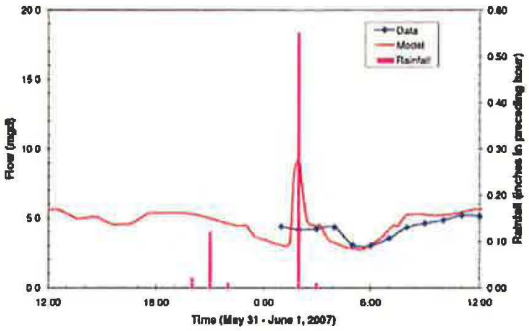
Quinnipiac Pump Station Wet Weather Verification - May 31, 2007



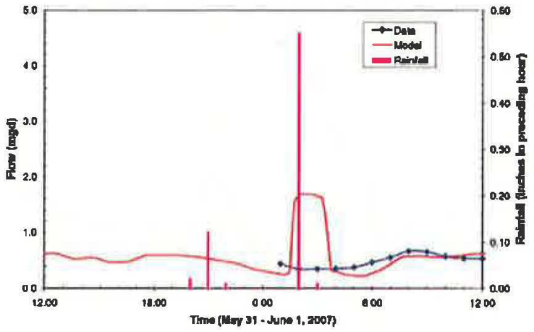
East Street Pump Station Wet Weather Verification - May 31, 2007



Morris Cove Pump Station Wet Weather Verification - May 31, 2007

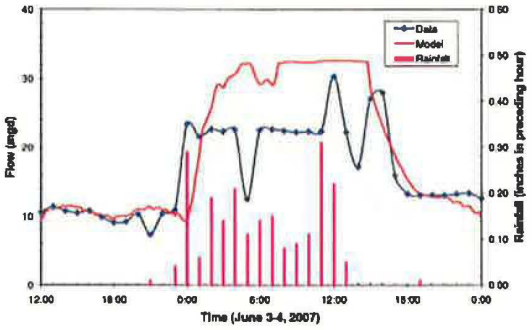


Barnes Pump Station Wet Weather Verification - May 31, 2007

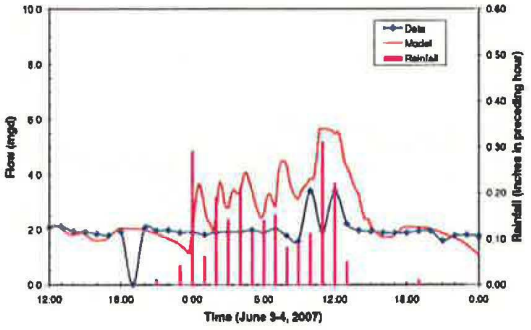


WET WEATHER FLOW VERIFICATION
Pump Stations – Event 3, June 3-4, 2007

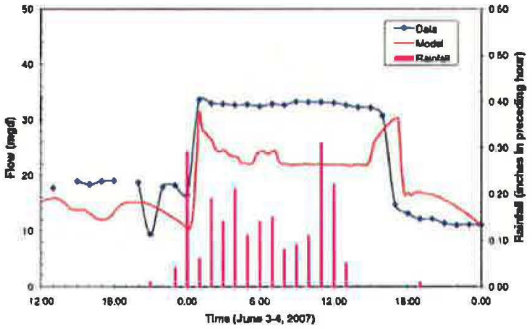
Boulevard Pump Station Wet Weather Verification - June 3-4, 2007



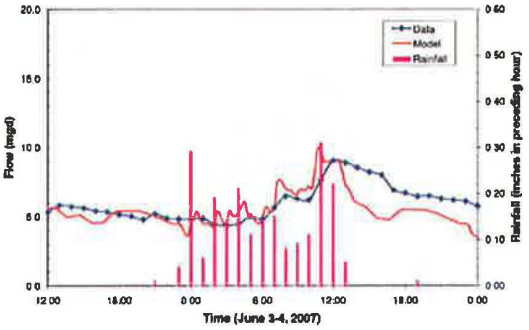
Quinnipiac Pump Station Wet Weather Verification - June 3-4, 2007



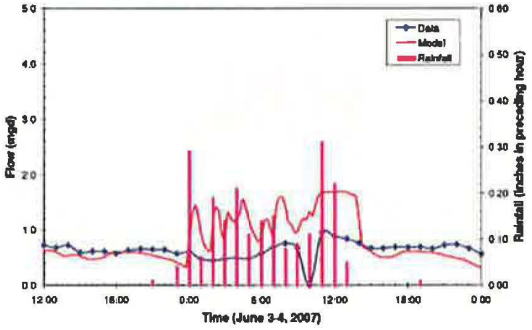
East Street Pump Station Wet Weather Verification - June 3-4, 2007



Morris Cove Pump Station Wet Weather Verification - June 3-4, 2007



Barnes Pump Station Wet Weather Verification - June 3-4, 2007



Greater New Haven Water Pollution Control Authority

Wet Weather Capacity Improvements – Hydraulic Model Update

Hydraulic Analysis: Long-term and Extreme Event Simulation

PREPARED FOR: GNHWPCA

PREPARED BY: CH2M HILL

DATE: September 13, 2007

PROJECT NUMBER: 350590

Introduction

During recent modeling activities to support Preliminary Engineering for Wet Weather Capacity Improvements, it was found that the planning-level hydraulic modeling scenarios previously developed to support the Greater New Haven Water Pollution Control Authority ("the Authority") Long-term Control Plan (LTCP) no longer reflects the collection system as it exists today. In the time since development of the LTCP model in 1997, several changes have occurred in the New Haven collection system, such as sewer separation projects, regulator modifications, and conventional growth and development. The Authority is conducting a Hydraulic Model Update task to update the model, verify that it accurately represents existing conditions, and to have a more current tool for evaluating engineering alternatives for its Wet Weather Preliminary Engineering project.

Several model update efforts are now completed. The Authority's hydraulic model was updated to reflect 2007 existing conditions in the collection system, as described in the August 1, 2007 *Hydraulic Model Improvements* technical memorandum. A monitoring program was conducted in May and June 2007 and documented in the *Short-Term Flow Monitoring Program* technical memorandum, dated August 16, 2007. The model was evaluated and adjusted to accurately simulate existing conditions, which was documented in the *Model Performance Verification* technical memorandum, dated September 13, 2007. The Model Performance Verification included recommendations to improve model accuracy, but the Existing Condition model was verified as accurate for hydraulic analyses. The purpose of this technical memorandum is to document the preparation and execution of model scenarios for the two-year design storm, an extreme event simulation, and a long-term analysis consistent with regional permit-related efforts and the federal CSO Control Policy.

Hydraulic Model Scenarios

The goal of the Hydraulic Model Improvements subtask is to prepare an updated hydraulic model suitable for continued planning purposes, with the following scenarios:

- 2007 Existing Condition – represents the collection system as it exists today;
- 2007 STCP Conditions – represents 2007 Existing Conditions with the addition of all STCP recommendations as defined in the LTCP Final Report (CH2M HILL, 2001) with some modifications as documented herein; and,
- 2007 LTCP Conditions – represents 2007 Existing Conditions with the addition of all STCP and LTCP recommendations as defined in the LTCP Final Report (CH2M HILL, 2001) with some modifications as documented herein.

2007 Existing Conditions Model

Several steps in the construction of the 2007 Existing Conditions Model were documented in the previous technical memorandums. Collection system information and data was compiled on sewer separation projects, pump stations, cross connections, CSO regulators and outfalls, and the construction and operation of the Truman Tank. The Existing Conditions Model was then constructed to represent the Authority's collection system as it operates currently. One dry and three wet weather events were selected for model assessment and verification. The assessment indicated that system hydraulics has changed and additional adjustments were required to improve model accuracy. The model was then verified as accurate for performing hydraulic analyses.

Short-Term Control Plan Model

The Short-term Control Plan Model (STCP Model) includes the projects that were recommended as part of the STCP that have been either built as of 2007 or are planned to be built. The STCP model contains many of the same updates as the Existing Conditions model. In order to compare performance measures between the Authority's STCP, LTCP, and the Existing Condition, the STCP Model did not include some elements of the Existing Condition model. For instance, to maintain consistency with the STCP, the STCP Model does not include the Truman Tank because the tank is a LTCP recommendation.

Long-Term Control Plan Model

The Long-Term Control Plan Model (LTCP Model) includes the projects that were recommended in the LTCP. The LTCP Model contains many of the same updates as the 2007 Existing Conditions model, including the Truman Tank. Modifications were made to the model to simulate additional LTCP elements, such as pump station capacity increases, conveyance improvements, and additional storage tanks. The following describes the pump station recommendations and model settings:

- The Boulevard Pump Station capacity was recommended to be increased to operate with a maximum capacity of 14.4 mgd for each pump in the current 3+1 manner with three of the pumps available for operation and one held in reserve for emergency situations. This is a maximum operating capacity of 43.2-mgd, compared to 34.6 mgd in the Existing Conditions model.

- No changes were recommended in the LTCP for the Union Street Pump Station. However, the original LTCP effort used a maximum capacity of 19 mgd at the pump station, based on information available at the time. The Existing Conditions included an update of the Union Street Pump Station representation to simulate it with its actual maximum capacity of 22.2 mgd. The 22.2-mgd capacity was used in the LTCP Model.
- Following an LTCP recommendation, the Long Wharf Pump Station capacity was increased from 1.0 mgd to 3.2 mgd.
- The East Street Pump Station capacity was recommended to be increased by 17 mgd above the existing condition of 42.8 mgd. Therefore, the maximum operating capacity of the pump station is 62.7 mgd in the LTCP Model.

Conveyance updates were also included in the LTCP Model. Pipe diameters were increased to 2.5 feet along Ramsdell Street to help alleviate street flooding and sewer backups, and a parallel relief sewer was added along Whalley Road. CSO 006 was modified to divert more flow to a storage facility instead of towards the overflow. The pipe diameter at CSO 013 was increased to 4.5 feet and several pipe diameters were increased along Chapel Street from 1.0 feet to 2.0 feet. CSO 019 (N. Front/Pine) was also removed from the model to correspond with the LTCP recommendation to eliminate it.

The original hydraulic model used during development of the LTCP did not simulate the recommended storage tanks. Rather, tank recommendations were sized to capture the calculated overflow volume remaining with other alternatives for the 2-year design storm. This modeling effort only simulated the Truman Tank based on the Existing Conditions Model. Post-simulation calculations were made on overflows where storage is recommended to account for CSO control attained by the recommended tanks that capture 100 percent of the 2-year design storm. Total overflows were reduced by the recommended tank size and added to WPAF volume treated assuming that all captured volumes will be drained and treated.

Two-Year Design Storm Hydraulic Analysis

The two-year design storm was simulated to analyze the effectiveness and benefits of the Short-Term and Long-Term Control plans and the 2007 Existing Conditions using the LTCP planning event. The LTCP event is a 2-year design storm has a 50 percent likelihood of occurring in any given year. The precipitation occurs over 6 hours, with a peak intensity of 2.15 inches/hour occurring over 15 minutes, and a total volume of 2.05 inches, as illustrated in Exhibit 1. The order of the analysis is the STCP, Existing Conditions, and LTCP. Comparisons are made to the STCP as a baseline since the Existing Condition reflects all elements of the STCP plus the Truman Tank, thus showing the benefits at this stage of implementing the STCP/LTCP. Exhibit 2 summarizes the results of the 2-year design storm analysis.

EXHIBIT 1
Rainfall Hyetograph for 2-year Design Storm Hydraulic Analysis

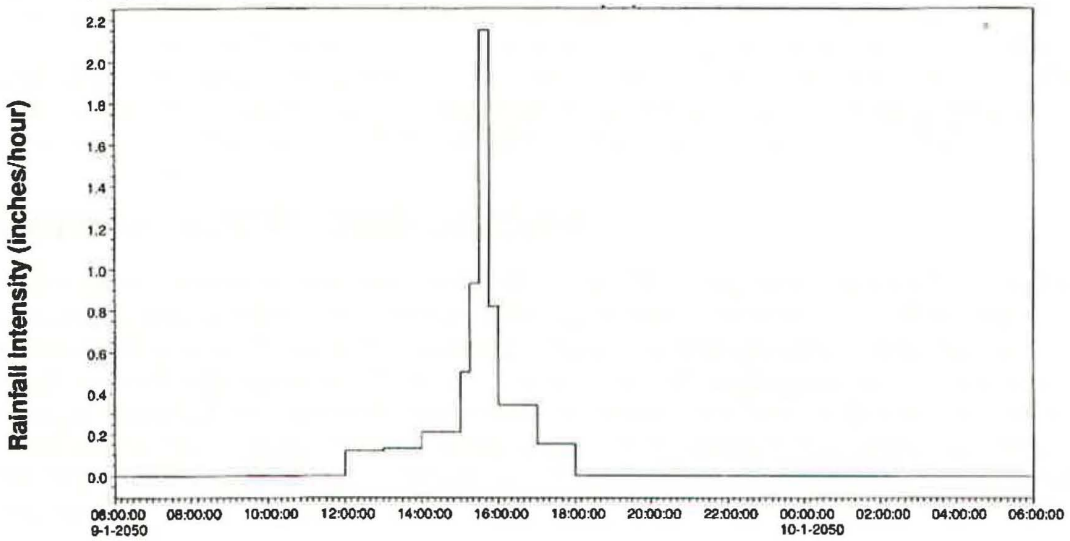


EXHIBIT 2
Collection System Performance and WPAF Treatment Benefits for the 2-year Design Storm Hydraulic Analysis
Comparisons are made using the STCP as a baseline condition.

Performance Measure	Short-Term Control Plan	2007 Existing Conditions	Long-Term Control Plan
Boulevard Pump Station Peak Flow (mgd)	33.6	33.2	36.4
East St. Pump Station Peak Flow (mgd)	27.3	27.3	30.9
Union St. Pump Station Peak Flow (mgd)	22.2	22.2	32.3
WPAF Peak Flow (mgd)	109	113	121
WPAF Volume Treated (MG)	45.3	46.3	99.3*
Volume Treated Improvement	-	2%	119%
CSO Overflow Volumes:			
West River (MG)	24.0	19.7	0*
Beaver Ponds (MG)	0.15	0.16	0*
Mill River (MG)	14.2	14.2	0*
Quinnipiac River (MG)	8.10	7.43	0*
New Haven Harbor (MG)	11.1	11.1	0*
Total	57.7	52.7	0*
Overflow Capture Improvement	-	9%	100%*

*LTCP recommends evaluations and design to construct tanks to eliminate overflows. Captured volumes would be treated at the WPAF.

EXHIBIT 4
Pump Station and WPAF Performance During an Extreme Event
Using the 2007 Existing Conditions Model

Location	Existing Maximum Pump Capacity (mgd)	Peak Calculated Flow (mgd)
Boulevard Pump Station	34.6	32.1
East Street Pump Station	42.9	34.0
Union Street Pump Station	22.2	22.2
East Shore WPAF		141.8

The pump station calculations indicate that the Boulevard and Union Street Pump Stations are reaching their maximum existing capacity. The calculation for the East Street Pump Station shows that maximum conveyance is not being achieved. This may be due to a model calculation issue that was revealed during the model verification. Additional analyses and model adjustments were recommended to improve the accuracy of the Boulevard and East Street Pump Station simulation. Since the force main goes directly to the WPAF, with model adjustments the combined pumping from the two stations should be calculated to be greater than the combined 36.1 mgd shown above, also increasing WPAF peak flows, by 11.4 mgd.

This simulation also shows that a large increase in peak flow is being calculated at the WPAF. The 2-year design event simulation with the 2007 Existing Conditions model calculated a peak treatment flow of 112.7 mgd. The calculated extreme event peak flow of 141.8 mgd is 25.7% greater than what is reached during a 2-year event. This indicates that there is additional capacity in the system that can be used to maximize conveyance, improve CSO capture, and reduce overflows.

Long-Term Hydraulic Analysis

The City of New Haven was the first combined sewer overflow (CSO) permittee in the State of Connecticut to have an approved LTCP, in 2001. The Authority was instructed to develop a LTCP to achieve 100 percent CSO control of the 2-year design storm condition. However, the design condition is not sufficient to evaluate overflow frequency and volume on a "typical year" basis, as defined and recommended in the federal CSO Control Policy. As such, the Authority performed a long-term analysis using an average year for consideration in LTCP development; using the 1967 rainfall record at Tweed Airport. This long-term hydraulic analysis updated the long-term analysis to develop a current tool to evaluate and implement LTCP alternatives, and make it consistent with permit-related issues and the federal CSO Control Policy. Calculations made for this analysis should be considered preliminary since additional model work would be required to refine the analysis to a planning level tool for detailed planning.

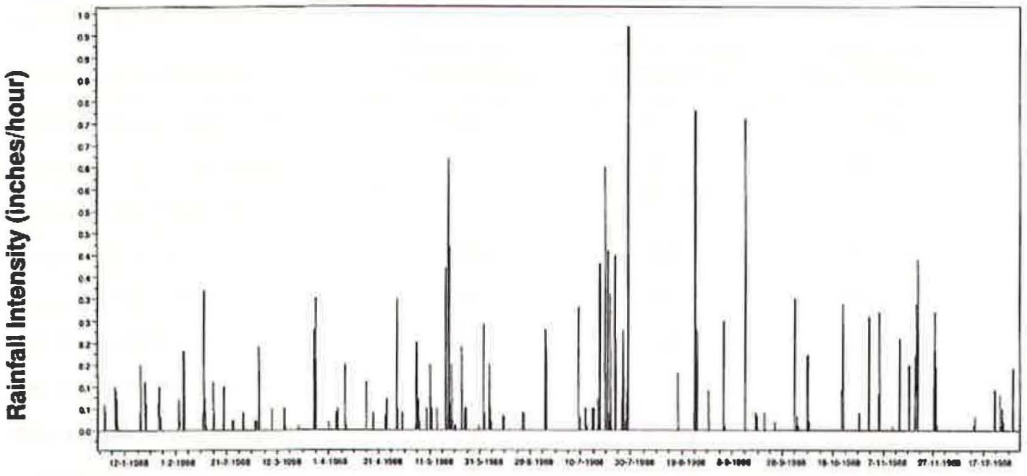
The 2-year design storm is a short duration, high intensity event that challenges the system to convey an extreme flow over a very short period of time. This type of event provides a

good indication of how the system reacts dynamically under an extreme condition. Planning to a single design event is a common engineering practice for designing conveyance and treatment to achieve a performance objective, such as controlling the 2-year design storm. However, a single event does not necessarily provide an opportunity to adequately analyze the benefits of maximized storage, conveyance, and treatment alternatives for sustained or multiple events. A single event does not facilitate an assessment of the frequency of overflows, which is also a consideration for LTCP development. Therefore model simulations were performed using a long-term period of wet weather to further quantify the benefit of the STCP/LTCP throughout the system.

Collection system CSOs and the WPAF discharge to waters tributary to Long Island Sound. Long Island Sound (LIS) is an impaired waterbody that has a Total Maximum Daily Load (TMDL) assigned to it limiting total nitrogen discharges. The TMDL is based on long-term mathematical modeling simulations. The Authority has WPAF permit limits for total nitrogen based on the TMDL. The current LIS modeling tool is being updated to simulate a typical year similar to that being used by the New York/New Jersey Harbor Estuary Program for its TMDL calculations. Future TMDL requirements will be based on this typical year. Therefore, it was selected as the long-term condition for this analysis.

The typical year being used for the LIS TMDL and other TMDL and LTCP planning efforts is the hourly rainfall record recorded at John F. Kennedy International Airport (JFK) in 1988. This typical year was originally selected by the New York City Department of Environmental Protection (NYCDEP) for its LTCP development and is also specified for LTCP development by the State of New Jersey. The year 1988 JFK rainfall record was selected as a typical year by the NYCDEP based on total rainfall, average event volume and intensity, frequency of events, and other statistical measures. The year had 40.7 inches of rainfall over more than 50 wet weather events. Exhibit 5 illustrates the rainfall hyetograph for the 1988 JFK rainfall record.

EXHIBIT 5
Typical-year Rainfall Hyetograph for Long-term Hydraulic Analysis
Hourly Rainfall Recorded in 1988 at John F. Kennedy International Airport



There are a large number of nodes and pipes in collection system hydraulic model. A calendar year simulation requires more than 24 hours of simulation time to execute. The typical year had over 50 wet weather events. Therefore, the simulation split the rainfall record into discrete 52 events; stripping out events of minor rainfall that would not be expected to induce an overflow. A summary of long-term simulation results are listed in Exhibit 6 for a number of performance measures. Comparisons are again made to the STCP as a baseline.

to be reduced to 12 overflow events for the LTCP, the most occurring to the West River at several outfalls along the Boulevard interceptor.

These calculations should be considered preliminary since additional model work would be required to refine the analysis to a planning level tool for detailed planning. But the modeling tools are now in place for use by the Authority.

Conclusions and Recommendations

Model scenarios were reconstructed using the verified Existing Conditions Model to simulate the STCP and LTCP for the current plan condition, a two-year storm. To better identify maximum conveyance capacity, a simulation was constructed and executed for a hypothetical extreme wet weather event to provide an indication of how the system operates under extreme conditions. A long-term hydraulic analysis, consisting of the typical year, was also performed for the STCP, Existing Conditions, and LTCP scenarios. The simulations can be used as a tool to calculate how the proposed STCP and LTCP improvements affect maximized conveyance, and overflow frequency and volume on a "typical year" basis to evaluate and implement LTCP alternatives, and make it consistent with permit-related issues and the federal CSO Control Policy.

The 2-year design storm analysis indicated that improvements are being realized with implementation of the STCP and other actions including the construction of the Truman Tank. The Extreme Event analysis indicates that additional capacity is in the existing system that can be utilized to maximize conveyance. This event can be applied to other preliminary engineering analyses to calculate maximum system performance achieved with design alternatives. The Long-term Hydraulic Analysis now provides a tool to evaluate not only increased capture and treatment, and reduced overflow volumes, but also the frequency of events that are or will be occurring with LTCP implementation.

The following is recommended:

- Implement the modeling recommendations in the September 13, 2007 *Model Performance Verification* technical memorandum that will improve model accuracy and provide an even better planning tool for the Authority.
- Further analyze and utilize the performance measures used in the 2-year design storm and Long-term Hydraulic Analysis as planning proceeds
- Regularly update the hydraulic model to reflect CSO-related projects and programs to better realize their benefits and plan for future actions as the LTCP is implemented.

Greater New Haven Water Pollution Control Authority Long Term Control Plan (LTCP) Simulation and Program Cost Update

PREPARED FOR: Greater New Haven Water Pollution Control Authority (GNHWPCA)

PREPARED BY: CH2M HILL

DATE: May 5, 2008

Introduction

As a result of the Preliminary Engineering for Wet Weather Capacity Improvements and the Hydraulic Model Updates (CH2M HILL 2008), the design requirements of various projects and other recommendations outlined in the CSO LTCP (CH2M HILL 2001) have been further refined. The intent of the CSO LTCP as it was laid out in 2001 was to provide a conceptual framework for projects to abate New Haven's CSOs over the next 15 years. The LTCP included some short-term projects to provide immediate results while additional study was to take place to further refine the long-term components of the plan. The work referenced above includes additional study to further refine some aspects of the original LTCP. The additional study includes further analysis of maximizing flows through the collection system to the East Shore Water Pollution Abatement Facility (WPAF), additional sewer separation, and the reduction in size or elimination of various CSO storage tanks.

This Technical Memorandum (TM), covers the following:

- Summary of the Updated 2007 Existing Conditions Model and Results
- Summary of the Updated LTCP Scenarios I and II Models, Results, and Costs
- Conclusions and Recommendations

Summary of the Updated 2007 Existing Conditions Model

Hydraulic model updates for the 2007 Existing Conditions Model were prepared for the GNHWPCA by CH2M HILL and are documented in *Technical Memorandum – Task 2, Wet Weather Capacity Improvements – Hydraulic Model Update – Hydraulic Model Improvements, dated April, 2008 (Task 2 TM).*

The 2007 Existing Conditions model includes:

- Short-term controls with minor modifications as noted in the Task 2 TM with the exception of the WPAF capacity improvements
- On-going pump station improvements (Barnes, Quinnipiac)
- Truman Tank

Although several tanks along E.T. Grasso Boulevard were included in the LTCP, tanks were not included as short-term projects. The initial concept of the LTCP was to maximize conveyance to the WPAF, correct sewer capacity deficiencies, and remove wet weather influences as possible, particularly from the separate sanitary towns north of the City, and further downsize storage needs. However, land became available near the overloaded Boulevard Interceptor. Due to pre-existing contamination in the Truman School's new parking area, a large hole would be dug to remove contaminated sediments. A mutually-beneficial agreement was reached to work with the school revitalization program to develop CSO storage beneath the school's new parking area. This school revitalization program had an immediate schedule; therefore, development of the Truman Tank began in 2002 and diverted attention and resources away from the originally-planned WPAF capacity improvements. The Truman Tank has provided and will continue to provide valuable data as a pilot program to any future storage programs in New Haven.

Results of the 2007 Existing Conditions Model using the 2-year design storm are presented in Table 1. Results of the 2007 Existing Conditions Model using the 1967 annual precipitation record are presented in Table 2.

Note: Although some precipitation events in the 1967 annual record may be close in some characteristics of the 2-year design storm, the 2-year design storm is more severe and therefore produces higher individual event results.

Summary of the Updated LTCP Scenarios I and II Models, Results and Costs

LTCP Scenarios I (147 mgd) and II (187 mgd) were developed for the GNHWPCA by CH2M HILL in *Technical Memorandum 1A, Wet Weather Capacity Improvements Project Definition TM 1A – Collection System Hydraulic Modeling, dated April 8, 2008 (TM 1A).*

LTCP Scenarios I and II can be described as follows:

Performance Measure	2007 Existing Conditions	(147 mgd) Scenario I	(187 mgd) Scenario II
Maximum Flow, Boulevard (mgd)	33	44	48
Maximum Flow, East St. (mgd)	29	51	48
Maximum Flow, Union St. (mgd)	22	22	57
WPAF Maximum Flow (mgd)	115	147	187
WPAF Volume Treated (MG)	49	52	56
% Volume Treated Improvement		**6%**	**14%**

Additional details of the LTCP include those originally proposed in the April 2001 CSO Plan including complete sewer separation in Fair Haven are provided in Table 3.

A summary of the model results using the 2-year design storm and the 1967 annual precipitation record are provided in Table 4 and Table 5, respectively.

Conclusions and Recommendations

The 2007 Existing Conditions is the updated baseline for the City of New Haven Long-Term Control Plan. The next phase of the program includes maximizing conveyance and treatment at the existing East Shore Water Pollution Abatement Facility. This will include upgrades to the two significant pump stations: Boulevard and East Street Pump Stations. Two LTCP scenarios are under consideration: 1) LTCP Scenario 1 (maximizing conveyance @ 147 mgd flow to the WPAF) and LTCP Scenario 2 (maximizing conveyance @ 187 mgd flow to the WPAF). Sewer system investigations also need to continue to reduce inflow and infiltration cost-effectively throughout New Haven and the GNHWPCA sewershed. Another component of the LTCP has been to reduce chronic sewer backups and street flooding where problems are still occurring under 2-year design storm conditions. The following presents conclusions and recommendations of this LTCP update.

Conclusions

- The short term controls implemented through 2007 provided more than a 20% decrease in CSO discharges citywide for the 2-year design storm.
- The 5 MG Truman Tank reduced CSO discharges to the West River and New Haven Harbor for a 2-year storm.
- Sewer separation projects reduced CSO discharges to the Mill River by about 27% for the 2-year design storm.
- Pump station improvements and sewer separation projects reduced CSOs to the Quinnipiac River by about 25% for the 2-year design storm.
- The model results of the 2007 Existing Conditions under 1967 annual precipitation conditions emphasizes the diverse characterization of New Haven's CSOs, highlighting frequent and heavy overflow locations versus infrequent short duration overflow locations.
- LTCP Scenario 1 provides about 28% CSO reduction over 2007 Existing Conditions and 44% CSO reduction over 1997 Existing Conditions, some along the Mill River, but mostly in New Haven Harbor at a revised cost of approximately $288 million.
- LTCP Scenario 2 provides about 37% CSO reduction over 2007 Existing Conditions and over 50% CSO reduction over 1997 Existing Conditions, some again along the Mill River, but mostly in New Haven Harbor at a revised cost of approximately $298 million.
- Refinements to the LTCP program in 2001 versus the LTCP program in 2008 include conveying increased flows to the plant and greater and more complete sewer separation, thus reducing the number of storage facilities needed at a comparable cost and upgrading critical components of existing conveyance and treatment infrastructure. In addition, the structure and jurisdiction of the Authority has changed over this time and the Authority now has responsibility for the sewer system infrastructure of all the towns that contribute flows to the WPAF; therefore, inflow/infiltration reduction in the sanitary systems north of New Haven which have indicated wet weather influence are an additional element of the updated plan.

TABLE 1

CSO Volumes and Duration From 2-Year Storm Under Differing Sewer System Conditions

CSO #	Location	1997 Existing Conditions	2007 Existing Conditions		Comments
	Target/Existing Flows (MGD) to WPAF		115		
		Vol. (MG)	Vol. (MG)	Duration (Hours)	
West River					
006	Whalley Ave. @ Fitch St.	4.6	5.1	6.5	
005	E.T. Grasso Blvd. @ Derby Ave.	5	4.8	6.5	basically unchanged
004	E.T. Grasso Blvd. @ Legion Ave.	6.1	6.1	8.0	no change
003	E.T. Grasso Blvd. @ Orange Ave.	4.3	3.1	5.8	Truman Tank Project reduces CSO at 003 and 002 and incorporates closure of 002
002	E.T. Grasso Blvd. @ Lamberton St.	1.1	closed	-	
	TOTAL	21.1	19.1		
Beaver Ponds					
008	Munson St. @ Orchard St.	0.2	0.2	1.8	no change
	TOTAL	0.2	0.2		
Mill River					
013	Everit St. @ East Rock Rd.	0.8	0.1	1.3	Short-term control (sewer separation) implemented
NA	Cross connection @ 013	0	closed	-	Short-term control implemented
012	Mitchell Dr. , east of Nicoll St.	2.7	1.5	4.3	Short-term control (sewer separation) implemented
NA	Mitchell Pump Station	0	0.0	0.0	
010	East St. @ I-91 (2 weirs) (upstream)	0.7	0.3	2.3	Short-term control (sewer separation) implemented
010	East St. @ I-91 (2 weirs) (downstream)	0.7	0.6	3.3	Short-term control (sewer separation) implemented
011	Humphrey St. @ I-91	9.9	7.4	4.8	
014	Trumbull St. @ Orange St.	0.9	1.0	2.3	
NA	Humphrey Pump Station	0.1	0.0	0.0	
009	Grand Ave. @ James St.	2.8	2.5	4.8	Short-term control (sewer separation) implemented
NA	East/Ives	0.7	0.5	3.8	Short-term control implemented
	TOTAL	19.3	14.0		
Quinnipiac River					
NA	Barnes Pump Station	0.3	closed	-	Pump station improvements implemented
NA	Quinnipiac Pump Station	*	closed	-	Pump station improvements implemented
018	Lombard St. @ North Front St.	1.7	closed	-	Short-term control (sewer separation) implemented
019	Pine St. @ North Front St.	1.5	1.3	4.0	Short-term control (sewer separation) implemented
020	Quinnipiac Ave. @ Clifton St.	0.2	0.6	8.0	Pump station projects affected flows
016	Poplar St. @ River St.	1.7	3.8	5.8	modifications in Fair Haven affected flows
015	James St. Siphon	4.6	1.7	3.8	Short-term control implemented
	TOTAL	10	7.5		
New Haven Harbor					
NA	S. Frontage/Davenport	*	0.9	2.8	unknown change; short term controls (sewer sepration)/Truman Tank may have reduced overflow
NA	Portsea/Liberty	*	0.0	0.0	
NA	Carlisle/Liberty	*	0.0	0.0	
021	East St. Pump Station	5.4	5.0	5.5	Short-term control (sewer separation) implemented
025	Union Pump Station	4.2	2.5	3.3	Short-term control (sewer separation) implemented
NA	George/Temple	1	0.9	2.3	
022	Allen Place	*	closed	-	Short-term control implemented
024	Boulevard Pump Station	3.5	0.6	4.8	Short-term control (sewer separation) implemented & Truman Tank reduces CSO at 024
NA	Woodward Pump Station	0.1	0.1	2.5	no change
	TOTAL	14.2	10.0		
	GRAND TOTAL (MG)	**64.8**	**50.7**		
	INCREMENTAL CSO REMOVED (MG)		**14.1**		

NOTES:

NA = Not Applicable; no NPDES number assigned

* = overflow not modeled; volume unknown

TABLE 2

CSO Volumes, Events, and Duration From 1967 Annual Precipitation

CSO #	Location	CSO Volumes (MG) for 2007 Existing Conditions	Total No. of Overflows	Duration of Overflows (hours)
West River				
006	Whalley Ave. @ Fitch St.	27.0	17	50
005	E.T. Grasso Blvd. @ Derby Ave.	22.0	37	129
004	E.T. Grasso Blvd. @ Legion Ave.	65.3	40	235
003	E.T. Grasso Blvd. @ Orange Ave.	12.5	28	70
002*	E.T. Grasso Blvd. @ Lamberton St.	10.4	0	0
	TOTAL	137.2		
Beaver Ponds				
008	Munson St. @ Orchard St.	0.0	0	0
	TOTAL	0.0		
Mill River				
013	Everit St. @ East Rock Rd.	0.4	1	2
NA	Cross connection @ 013	closed	0	0
012	Mitchell Dr. , east of Nicoll St.	2.9	11	17
NA	Mitchell Pump Station	0.0	0	0
010	East St. @ I-91 (2 weirs) (upstream)	0.7	2	4
010	East St. @ I-91 (2 weirs) (downstream)	1.7	5	6
011	Humphrey St. @ I-91	26.6	14	50
014	Trumbull St @ Orange St.	1.2	1	2
NA	Humphrey Pump Station	0.0	0	0
009	Grand Ave @ James St.	8.1	32	42
NA	East/Ives	1.3	8	9
	TOTAL	42.9		
Quinnipiac River				
NA	Barnes Pump Station	closed	0	0
NA	Quinnipiac Pump Station	closed	0	0
018	Lombard St. @ North Front St.	closed	0	0
019	Pine St. @ North Front St.	2.4	8	12
020	Quinnipiac Ave. @ Clifton St.	1.4	8	13
016	Poplar St. @ River St.	20.4	38	105
015	James St. Siphon	4.1	8	19
	TOTAL	28.3		
New Haven Harbor				
NA	S. Frontage/Davenport	0.8	4	7
NA	Portsea/Liberty	0.0	0	0
NA	Carlisle/Liberty	0.0	0	0
021	East St. Pump Station	35.1	44	76
025	Union Pump Station	9.0	6	14
NA	George/Temple	1.6	3	5
022	Allen Place	closed	0	0
024	Boulevard Pump Station	1.9	30	12
NA	Woodward Pump Station	0.1	4	9
	TOTAL	48.5		
	GRAND TOTAL (MG)	257.0		

NOTES:

* = CSO 002 was open when the 2007 Existing Conditions Model was run for the 1967 Annual Precipitation

NA = Not Applicable; no NPDES number assigned

Table 3

New Haven CSO LTCP Scenario I and II (Updated May 2008)

Location	2-Year Storm Impact	Modeled Scenarios (LTCP I and II)	Year 2008 Scenario 1 (147 mgd)	Year 2008 Scenario 2 (187 mgd)
BOULEVARD SEWERSHED				
Ramsdell	Eliminated street flooding	Increased 1,450 LF of 15" pipe and 250 LF of 10" pipe to 30" along Ramsdell Street from Fountain Street to Whalley Avenue; Increased 225 LF of 8" pipe to 15" along Fountain Street from Cooper Place to Ramdell Street, and increased 450 LF of 12" pipe to 24" along Lowin Avenue midway between Judwin Avenue and Fountain Street plus along Fountain Street between Lowin Avenue and Ramsdell Street. April 2001 LTCP construction cost estimate = $800,000 (Year 2000 $).	$3,400,000	$3,400,000
CSO 006 (Whalley/Fitch), Whalley/Blake	CSO = 0 MG, reduced street flooding	Constructed 6.1 MG storage tank. Added 8,600 LF of parallel sewer along Whalley Avenue from the City limits to Fitch Street (includes 6,565 LF of 30" diameter, 2,036 LF of 36" diameter, and 8 LF of 42" diameter pipe. Reconstructed regulator. This option was selected for modeling and cost estimating purposes, but other alternatives were noted in the April 2001 LTCP that warrant further investigation. April 2001 LTCP construction cost estimate = $15,800,000 (Year 2000 $).	$39,700,000	$39,700,000
CSO 008 (Munson/Orchard), Moreland/Goffe	CSO = 0.1 MG	Recommended sewer system investigation to reduce overflow. April 2001 LTCP cost estimate included roof leader disconnection, but there were concerns about implementation success rate; therefore, other options were to be pursued through sewer investigation, and no additional work was included in the model. March 2008 test run indicated that complete sewer separation would eliminate CSO 008. April 2001 LTCP construction cost estimate = $3,100,000 (Year 2000 $).	$4,700,000	$4,700,000
Chapel Street upstream of 005	Reduced street flooding	Increased 1,800 LF of 12" pipe to 24" along Chapel Street from Alden Avenue to Yale Avenue. April 2001 LTCP construction cost estimate = $600,000 (Year 2000 $).	$2,900,000	$2,900,000
CSO 005 (Boulevard/Derby)	CSO = 0 MG	Constructed 3 storage tanks totaling 13 MG. Recommended sewer system investigation to reduce sediment buildup and overflow and to reduce ultimate storage requirements. April 2001 LTCP cost estimate also included roof leader disconnection to reduce ultimate storage requirements, but there were concerns about implementation success rate; therefore, roof leader disconnection is not included in the model. April 2001	$59,200,000	$59,200,000
CSO 004 (Boulevard/Legion)	CSO = 0 MG			
CSO 003 (Boulevard/Orange)	CSO = 0 MG			
CSO 002 (Blvd/Lamberton)	None	CSO outfall has been closed. April 2001 LTCP construction cost estimate included construction of 0.9 MG storage tank and roof leader disconnection; however, Truman Tank Project eliminated this overflow. April 2001 LTCP construction cost estimate = $4,300,000 (Year 2000 $).	$1,400,000	$1,400,000
CSO 024 (Blvd Pump Station)	CSO = 0 MG	April 2001 LTCP cost estimate included construction of a 3.2 MG storage tank, minor pump station upgrades, and roof leader disconnection = $11,200,000 (Year 200 $). However, the Truman Tank Project significantly reduced this CSO. Revised LTCP recommendation includes upgrading the pump station to maximize its pumping capacity from 34.6 MGD to 47.5 MGD and eliminating the need for roof leader disconnection or storage.	$14,600,000	$14,600,000
Long Wharf Pump Station	Eliminated street flooding	Increased pump station maximum pumping rate from two (2) 350 gpm to two (2) 1120 gpm in conjunction with increasing the 145 LF force main diameter from 6" to 10". April 2001 LTCP construction cost estimate = $300,000 (Year 2000 $).	$500,000	$500,000

Table 3
New Haven CSO LTCP Scenario I and II (Updated May 2008)

Location	2-Year Storm Impact	Modeled Scenarios (LTCP I and II)	Year 2008 Scenario 1 (147 mgd)	Year 2008 Scenario 2 (187 mgd)
EAST STREET				
CSO 013 and nearby cross-connection (East Rock Road)	CSO = 0 MG	Short-term controls significantly reduced overflow; therefore, CSO outfall was recommended for closure. No further action needed. April 2001 LTCP cost estimate included roof leader disconnection = $1,200,000 (Year 2000 $).	$1,800,000	$1,800,000
CSO 012 (Mitchell/Nicoll)	CSO = 0.8 MG	Short-term controls significantly reduced overflow; however, CSO = 1.5 MG remained. April 2001 LTCP cost estimate included roof leader disconnection to reduce ultimate storage requirements, but there were concerns about implementation success rate; therefore, roof leader disconnection is not included in the model. Negotiation with neighboring communities to the north to reduce wet weather impacts in their sanitary sewers were recommended to reduce ultimate storage requirements; storage was limited to 0.7 MG. April 2001 LTCP cost estimate = $6,800,000 (Year 2000 $).	$11,900,000	$11,900,000
CSO 010 (East/I-91)	CSO = 0.3 MG (upstream) & 0.5 MG (downstream	Constructed storage tank totalling 6 MG and increased 824 LF of 18" pipe to 30" along State Street from Grove Street to Trumbull Street. April 2001 LTCP cost estimate included roof leader disconnection to reduce ultimate storage requirements, but there were concerns about implementation success rate; therefore, roof leader disconnection is not included in the model. Inflow reduction should eliminate CSO 010. April 2001 LTCP cost estimate = $6,800,000 (Year 2000 $).	$54,700,000	$54,700,000
CSO 011 (Humphrey/I-91)	CSO = 1.6 MG			
CSO 014 (Trumbull/Orange)	CSO = 0 MG			
East/Ives CSO	CSO = 0.1 MG	April 2001 LTCP cost estimate included roof leader disconnection, but there were concerns about implementation success rate; therefore, roof leader disconnection is not included in the model. Inflow reduction should eliminate the East/Ives CSO. April 2001 LTCP cost estimate = $800,000 (Year 2000 $).	$1,100,000	$1,100,000
Humphrey Pump Station	CSO = 0 MG; eliminated street flooding	Increased 530 LF of 18" pipe to 30" along Mill River Street and added an additional 20 LF of 10" pipe to 30" connecting this pipe to the pump station. Also increased the pumping capacity from 350 gpm to 1200 gpm in conjunction with increasing the force main diameter from 6" to 24". April 2001 LTCP cost estimate = $600,000 (Year 2000 $).	$1,100,000	$1,100,000
S. Frontage/Davenport CSO	CSO = 0.7 MG	Added 5,000 LF of 42" DI force main from Union Street Pump Station to the twin 42" Harbor Crossing valve on the west shore. Added another 5,000 LF of 36" DIP from East Shore valve to WPAF. Increased 75 LF of 8" and 15" parallel pipes to 24" pipes upstream of the pump station. Also increased pumping capacity from 22.2 MGD to 58.3 MGD. The plan components have been revised since the April 2001 LTCP cost estimate = $17,400,000 (Year 2000 $).	$21,100,000	$30,800,000
CSO 025 (Union Pump Station)	CSO = 0.2 MG			
George/Temple CSO	CSO = 0.8 MG			
Union/Columbus Avenues & Water Street	Eliminated street flooding			
CSO 021 (East Street Pump Station)	CSO = 0.2 MG	Increased pump capacity from 42.8 MGD to 51.8 MGD. April 2001 LTCP cost estimate also included roof leader disconnection, 0.6 MG CSO storage tank, but there were concerns about implementation success rate; therefore, roof leader disconnection is not included in the model. Inflow reduction should eliminate the CSO 021. April 2001 LTCP cost estimate = $5,500,000 (Year 2000 $).	$13,900,000	$13,900,000

Table 3

New Haven CSO LTCP Scenario I and II (Updated May 2008)

Location	2-Year Storm Impact	Modeled Scenarios (LTCP I and II)	Year 2008 Scenario 1 (147 mgd)	Year 2008 Scenario 2 (187 mgd)
EAST SHORE				
Barnes Pump Station	CSO = 0 MG; Reduced Street flooding	Pump station improvement projects completed and incorporated into 2007 Existing Conditions Model. CSO outfalls have been closed. April 2001 LTCP cost estimate = $3,700,000 (Year 2000 $), but no further CSO action needed.	$200,000	$200,000
Quinnipiac Pump Station	CSO = 0 MG; Reduced Street flooding	Increased 7,437 LF of sewer from 2.0 feet diameter to 3.5 feet diameter along Quinnipiac Avenue. Alam, I thought this was part of the pump station improvements as was included in Existing Conditions?	$300,000	$300,000
CSO 020 (Quinnipiac Ave/Clifton Street	CSO = 0 MG		$100,000	$100,000
CSO 018 (N. Front/Lombard)	CSO = 0 MG; Reduced Street flooding			
CSO 019 (N. Front/Pine)	CSO = 0 MG; Reduced Street flooding	Short-term controls/partial sewer separation significantly reduced CSOs. Complete sewer separation/roof leader disconnection performed. CSO 018, 019, 016, 015, and 009 have been closed. The plan components have been revised since the April 2001 LTCP cost estimate = $45,100,000 (Year 2000 $).	$55,000,000	$55,000,000
CSO 016 (Poplar/River)	None			
CSO 015 (James St. Siphon)	CSO = 0 MG; Reduced Street			
CSO 009 (James/Grand)	None			
Murphy/Market Pump Station	CSO = 0 MG; Reduced Street flooding	Increased the force main from 4" to 8". Alam, the pumping was supposedly increased, too, from 160 to 245 gpm. April 2001 LTCP cost estimate = $200,000 (Year 2000 $)	$300,000	$300,000
Morris Cove	Minor street flooding	Pump station improvement project completed and incorporated into 2007 Existing Conditions Model which also included 1,234 LF of 18" diameter pipe increased to 36" diameter pipe along Lighthouse Road and Morris Causeway between the Cove Street and the Morris Street PS. April 2001 LTCP cost estimate = $2,800,000 (Year 2000 $).	$300,000	$300,000
Woodward Pump Station	CSO = 0.1 MG	Sewer system investigations were to eliminate this CSO. April 2001 LTCP cost estimate included a 0.1 MG tank if needed = $800,000 (Year 2000 $).	$100,000	$100,000
CSO 022 (Allen Place)	None	CSO outfall has been closed	$100,000	$100,000
		TOTAL[1]	$288,400,000	$298,100,000

[1]- Costs represent construction cost escalated to mid-point of construction.

TABLE 4

CSO Volumes and Duration From 2-Year Storm Under Differing Sewer System Conditions Without Storage Tanks

CSO #	Location	1997 Existing Conditions	2007 Existing Conditions		Long-Term Control Plan (LTCP) Scenario #1		LTCP Scenario #2	
	Target/Existing Flows (MGD) to WPAF		115		147		187	
		Vol. (MG)	Vol. (MG)	Duration (Hours)	Vol. (MG)	Duration (Hours)	Vol. (MG)	Duration (Hours)
West River								
006	Whalley Ave. @ Fitch St.	4.8	5.1	6.5	6.1	5.8	6.1	5.8
005	E.T. Grasso Blvd. @ Derby Ave.	5	4.8	6.5	4.6	6.5	4.6	6.5
004	E.T. Grasso Blvd. @ Legion Ave.	6.1	6.1	8.0	5.7	7.3	5.7	7.5
003	E.T. Grasso Blvd. @ Orange Ave.	4.3	3.1	5.8	3.0	5.5	3.0	5.5
002	E.T. Grasso Blvd. @ Lamberton St.	1.1	closed		closed		closed	
	TOTAL	21.1	19.1		19.4		19.4	
Beaver Ponds								
008	Munson St. @ Orchard St.	0.2	0.2	1.8	0.1	1.5	0.1	1.5
	TOTAL	0.2	0.2		0.1		0.1	
Mill River								
013	Everit St. @ East Rock Rd.	0.8	0.1	1.3	closed		closed	
NA	Cross connection @ 013	0	closed		closed		closed	
012	Mitchell Dr. . east of Nicoll St.	2.7	1.5	4.3	1.6	4.3	1.5	4.5
NA	Mitchell Pump Station	0	0.0	0.0	0.0	0.0	0.0	0.0
010	East St. @ I-91 (2 weirs) (upstream)	0.7	0.3	2.3	0.4	2.5	0.3	2.3
010	East St. @ I-91 (2 weirs) (downstream)	0.7	0.6	3.3	0.7	3.5	0.5	3.0
011	Humphrey St. @ I-91	9.9	7.4	4.8	7.6	4.8	6.9	4.3
014	Trumbull St. @ Orange St.	0.9	1.0	2.3	1.0	2.3	1.0	2.3
NA	Humphrey Pump Station	0.1	0.0	0.0	0.0	0.0	0.0	1.3
009	Grand Ave. @ James St.	2.8	2.5	4.8	closed		closed	
NA	East/Ives	0.7	0.5	3.8	1.0	4.0	0.1	1.8
	TOTAL	19.3	14.0		12.3		10.4	
Quinnipiac River								
NA	Barnes Pump Station	0.3	closed		closed		closed	
NA	Quinnipiac Pump Station	*	closed		closed		closed	
018	Lombard St. @ North Front St.	1.7	closed		closed		closed	
019	Pine St. @ North Front St.	1.5	1.3	4.0	closed		closed	
020	Quinnipiac Ave. @ Clifton St.	0.2	0.6	8.0	0.0	0.0	0.0	0.0
016	Poplar St. @ River St.	1.7	3.8	5.8	closed		closed	
015	James St. Siphon	4.6	1.7	3.8	closed		closed	
	TOTAL	10	7.5		0.0		0.0	
New Haven Harbor								
NA	S. Frontage/Davenport	*	0.9	2.8	0.9	2.8	0.7	2.0
NA	Portsea/Liberty	*	0.0	0.0	closed		closed	
NA	Carlisle/Liberty	*	0.0	0.0	closed		closed	
021	East St. Pump Station	5.4	5.0	5.5	0.1	7.0	0.2	4.3
025	Union Pump Station	4.2	2.5	3.3	2.5	3.3	0.2	1.0
NA	George/Temple	1	0.9	2.3	0.9	2.3	0.8	2.3
022	Allen Place	*	closed		closed		closed	
024	Boulevard Pump Station	3.5	0.6	4.8	0.0	0.0	0.0	0.0
NA	Woodward Pump Station	0.1	0.1	2.5	0.1	2.5	0.1	2.5
	TOTAL	14.2	10.0		4.5		2.0	
	GRAND TOTAL (MG)	**64.8**	**50.7**		**36.4**		**32.0**	
	INCREMENTAL CSO REMOVED (MG)				14.3		18.7	

NOTES:

NA = Not Applicable; no NPDES number assigned

* = overflow not modeled; volume unknown

TABLE 1967

CSO Volumes (MG) From 1967 Storm Under Differing Sewer System Conditions

		2007 Existing Conditions Response			Projected LTCP I Conditions Response			LTCP II Conditions Response		
CSO #	Location	Volumes (MG)	Total No. of Overflows	Duration of Overflows (in hrs)	Volumes (MG)	Total No. of Overflows	Duration of Overflows (in hrs)	Volumes (MG)	Total No. of Overflows	Duration of Overflows (in hrs)
West River										
006	Whalley Ave. @ Fitch St.	27.0	27	82	5.6	31	104	5.0	28	93
005	E.T. Grasso Blvd. @ Derby Ave.	22.0	39	196	24.1	45	221	21.5	40	197
004	E.T. Grasso Blvd. @ Legion Ave.	65.3	44	282	72.7	51	320	64.7	45	285
003	E.T. Grasso Blvd. @ Orange Ave.	12.5	28	98	13.9	33	109	12.4	29	97
002	E.T. Grasso Blvd. @ Lamberton St.	10.4	1	1	closed	-	-	closed	-	-
	TOTAL	**137.2**	**139**		**116.2**	**159**		**103.5**	**142**	
Beaver Ponds										
008	Munson St. @ Orchard St.	0.0	0	0	0.0	0	0	0.0	0	0
	TOTAL	**0.0**	**0**	**0**	**0.0**	**0**		**0.0**	**0**	
Mill River										
013	Everit St. @ East Rock Rd.	0.4	1	0	closed	-	-	closed	-	-
NA	Cross connection @ 013	closed	-	-	closed	-	-	closed	-	-
012	Mitchell Dr., east of Nicoll St.	2.9	8	24	2.7	9	23	2.7	9	23
NA	Mitchell Pump Station	0.0	0	0	0.0	0	0	0.0	0	0
010	East St. @ I-91 (2 weirs) (upstream)	0.7	1	1	0.7	1	1	0.7	1	1
010	East St. @ I-91 (2 weirs) (downstream)	1.7	5	10	1.1	2	3	1.1	2	3
011	Humphrey St. @ I-91	26.6	15	55	17.2	15	42	17.2	15	42
014	Trumbull St. @ Orange St.	1.2	1	1	1.2	1	0	1.2	1	1
NA	Humphrey Pump Station	0.0	0	0	0.0	0	0	0.0	0	0
009	Grand Ave. @ James St.	8.1	27	66	closed	-	-	closed	-	-
NA	East/Ives	1.3	7	15	0.4	0	0	0.4	0	0
	TOTAL	**42.9**	**65**		**23.3**	**28**		**23.3**	**28**	
Quinnipiac River										
NA	Barnes Pump Station	closed	-	-	closed	-	-	closed	-	-
NA	Quinnipiac Pump Station	closed	-	-	closed	-	-	closed	-	-
018	Lombard St. @ North Front St.	closed	-	-	closed	-	-	closed	-	-
019	Pine St. @ North Front St.	2.4	7	19	closed	-	-	closed	-	-
020	Quinnipiac Ave. @ Clifton St.	1.4	6	20	0.2	0	0	0.2	0	0
016	Poplar St. @ River St.	20.4	45	157	closed	-	-	closed	-	-
015	James St. Siphon	4.1	9	24	closed	-	-	closed	-	-
	TOTAL	**28.3**	**67**		**0.2**	**0**		**0.2**	**0**	
New Haven Harbor										
NA	S. Frontage/Davenport	0.8	4	9	0.0	0	0	0.0	0	0
NA	Portsea/Liberty	0.0	0	0	closed	-	-	closed	-	-
NA	Carlisle/Liberty	0.0	0	0	closed	-	-	closed	-	-
021	East St. Pump Station	35.1	23	95	1.5	1	1	1.3	1	1
025	Union Pump Station	9.0	6	17	9.0	6	17	0.0	0	0
NA	George/Temple	1.6	3	7	1.6	2	5	1.5	2	5
022	Allen Place	closed	-	-	closed	-	-	closed	-	-
024	Boulevard Pump Station	1.9	0	0	1.9	0	0	1.9	0	0
NA	Woodward Pump Station	0.1	3	3	0.1	3	3	0.1	3	3
	TOTAL	**48.5**	**39**		**14.2**	**12**		**4.9**	**6**	
	GRAND TOTAL (MG)	**257.0**			**153.9**			**131.9**		
	INCREMENTAL CSO REMOVED (MG)				**103.1**			**125.0**		

NOTES

NA = Not Applicable; no NPDES number assigned